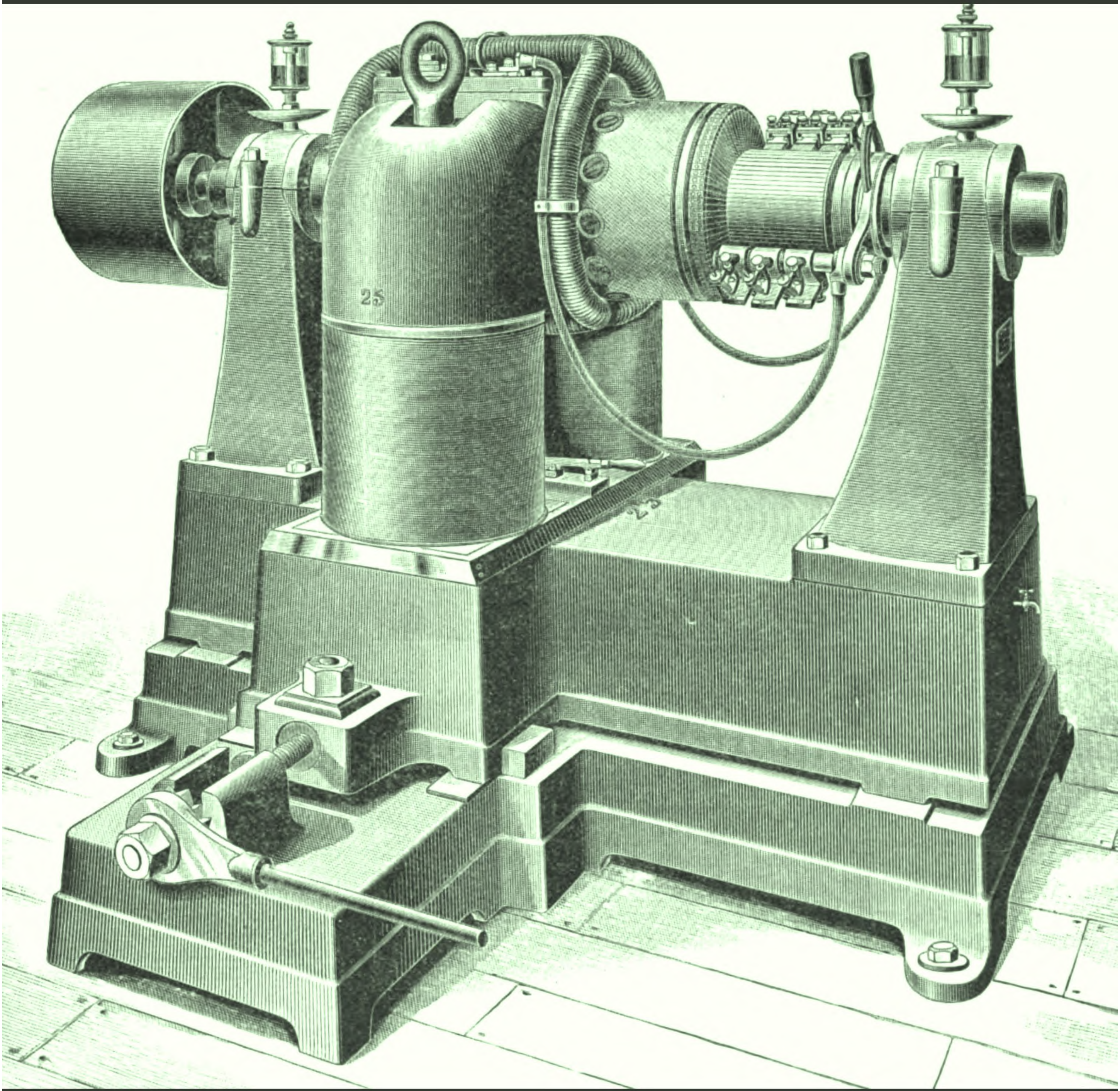

Electrical engineer

THE ELECTRICAL ENGINEER.

A Monthly Review of Theoretical and Applied Science.

VOLUME VIII.—1889.

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ELECTRICAL ENGINEER.

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Conducted by F. L. POPE AND G. M. PHELPS.

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Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers.*

VOL. VIII. NEW YORK, JANUARY, 1889. No. 85.

SOME COMMERCIAL ASPECTS OF THE ELECTRIC LIGHTING BUSINESS.

ACCORDING to the figures given in the address of President Duncan, at the National Electric Light Convention in this city last summer, which subsequent investigations have convinced us were not overstated, there were then in use in the United States nearly 200,000 arc lights and nearly 2,000,000 incandescent lights, while the total horse-power of the engines employed in producing the electric current for operating them was in round numbers no less than 460,000. Taking into consideration the increase since that time, there can be no doubt that up to the end of the year 1888, a sum not less than $100,000,000 in cash or its equivalent has been expended by local illuminating companies and private consumers for the equipment and installation of electric lighting plants. No small share of this money has passed into the hands of four or five of the principal electric lighting companies doing business in the United States; but it is nevertheless an open secret that the instances in which the stockholders of these companies have received any substantial return for their investment have up to the present time been few and far between. It is a fact, patent to all, that a great share of the money has been absorbed by inventors, promoters, salesmen, lawyers, experts and sinecurists, great and small, too numerous to mention.

We have hitherto remarked on two or three occasions that indications are not wanting that this state of affairs is approaching its end. The law of the survival of the fittest is bound to assert itself sooner or later among electric lighting companies just as certainly as it has among railway, telegraph and other enterprises. It is the inevitable experience that the great companies get control of the smaller ones, and the profitable ones absorb the unprofitable ones. This result comes about from the operation of a commercial law, the processes of which can neither be retarded nor hastened to any considerable degree by the manipulations of individuals or of cliques.

We have been led to express these opinions by the occasional appearance of more or less detailed assertions in respect to consolidation alleged to be impending between the Edison Electric Light Company and the Westinghouse Electric Company. While it may be set down as certain that there is no truth in the rumors in the form in which they have reached the public, yet the progress of events makes it perfectly clear that, sometime in the future, commercial considerations must compel a certain harmonizing of conflicting interests between three or four of the most important electric lighting companies, which, as things are now going on, will soon be the only ones left in the field.

We venture to make this prediction, for the reason that the leading companies are coming more and more under the control of hard-headed business men, who well understand that it is for their interest to do business; to make money instead of to waste it, as has too often been the way in the past. Moreover, those who are thoroughly familiar with the general situation understand perfectly well that while the existing condition of affairs renders it futile for any one company to hope to control the electric lighting business to the exclusion of competitors by means of its patents, the combination of a few patents, which might be selected from among those owned by different and in many cases, hostile interests, if wielded by a compact and powerful executive, would not only control the business situation, but would render it possible for much better service to be given the public, and at a far greater profit to the stockholders than is now possible. Hence, nothing can be more certain than that the necessities of the situation will operate more and more powerfully as time goes on to bring about, if not union, at least harmony of interests in the direction we have indicated for the benefit of all.

DOGMATIC.

NOBODY is surprised, as a rule, at the chorus of ki-yies which is wont to arise from the kennel when a strange dog unexpectedly drops in and carries off a particularly large and delicious bone. Good old Dr. Isaac Watts philosophically bids us

> "Let dogs delight to bark and bite,
> For 'tis their nature to."

But we cannot restrain some expression of regret when we find our hitherto esteemed contemporary, the *Electrical Review*, of London, so far losing its temper as to indulge in ill-natured and currish remarks, such as we find in its issue of November 23d, in reference to the award of the contract for equipping the Sardinia street central station in London, to an American concern. It says:—

Now why is it that American contractors can beat us on our own ground? We can scarcely believe it to be on the score of price, and we fail to see how it is on the ground of extra efficiency. * * * * It is not as if we would not or could not do the thing decently.

Our contemporary then proceeds to answer its own question by inferentially imputing to the directors of the Metropolitan Electric Supply Company bad faith in respect to the opening of the tenders, and, still worse, makes what can only fitly be characterized as a scurrilous and unjustifiable attack upon the professional reputation of one of the consulting engineers of the Metropolitan company, whom it is impossible not to identify, even at this distance, as Professor George Forbes. It then adds as a sort of clincher:—

Moreover the directors (of the Metropolitan Electric Supply Company, Limited) Messrs. Pender, Anderson & Co., cannot well pose as patriots.

Quite so, esteemed contemporary! Your last shot was a bull's-eye. Messrs. Pender, Anderson, Elliott & Co., so far from being patriots, can pretend to be nothing more than mere trustees of a limited company ostensibly established for no higher purpose than that of making money. To this base and ignoble end they propose to convert coal into electricity, and sell it at a profit to the public (who, alas! are only too anxious to buy), and to distribute the net proceeds of this nefarious operation among the stockholders. Why, indeed, should these guinea-jinglers seek to pose as patriots?

No, the only thing apparently desired by them was to get their works in operation and earning money at the earliest possible moment, and so, in the most unpatriotic manner, they awarded the contract to parties who showed themselves best prepared to complete it promptly; who had executed in a satisfactory manner a vast amount of precisely similar work, and who were ready to guarantee to put down, and have in operation at a given time, a plant which should be capable of earning dividends from the day the steam should be turned on. We have plenty of such plants in the United States; but any one familiar with the endless catalogue of mistakes, failures and disasters which make up the history of central station electric lighting in England, knows but too well that a commercially successful central station plant will be a most refreshing novelty in that country.

In any event, it appears that half-a-dozen central station installations, more or less, are now in process of being set up in London, to say nothing of the colossal enterprise at Deptford, of which we gave some account in our last issue. If any or all of these turn out to be better or cheaper than the American-built station, or capable of earning more money, then will the matter—though not the manner—of our contemporary's remarks be justified. For its unmanly assault upon Professor Forbes, whose only misdeeds appear to have been the sale of his rights in the United States to a patented meter, and his subsequent recommendation, which as an unprejudiced counsellor he was bound, when called upon, to make, of the Westinghouse system as the one which had given the best financial results in the United States, why not, with equal justice and good taste, attack Sir William Thomson for getting his own syphon recorder into use on the Atlantic cables, or Mr. Preece for introducing his own railway signals on the South Western line? We should say that when it is proven that the recommendations of Professor Forbes were immediately beneficial to himself, or prejudicial to the interests of the corporation he was called on to advise, it will be time enough to berate him in the extraordinary language which our contemporary has seen fit to employ.

THE SUBWAYS.

The Board of Electrical Control of New York, is sharply attacked by the *Evening Post* in its issues of December 31 and January 2, a considerable portion of both its news and editorial columns containing criticisms of the commission and its work. The burden of complaint is that permits are still given for the erection of overhead wires, and that there are more overhead wires in the city now than when the Subway Commission was created for the purpose of causing all electric conductors to be put underground. An investigation by the Legislature of the acts and omissions of the board is recommended.

By all means let us have an investigation. If made thoroughly, and with the assistance of disinterested electrical engineers in the technical part of the inquiry, it would no doubt clearly reveal the causes of the unsatisfactory outcome of the three years' work of the Subway Commission, or Board of Electrical Control, as it is now entitled. These causes, in our opinion, are two;—first, the inherent difficulty of the work proposed;—second, the absurdly inadequate, not to say ridiculous, composition of the board appointed to plan and execute it. On these points the Electrical Engineer has several times expressed its views. Taken together they fully account for the situation. A board of competent men, totally unconnected with politics and unskilled in "deals," might not, perhaps, have put more wires underground, but would have brought the city much nearer a solution of the electric wire problem than it is at present. They would have made a more intelligent study of the undertaking before them, realizing that nothing like putting the entire electric service of a great city underground had been anywhere accomplished; and would not have placed the construction and management of the subways in the hands of a stock company. The ownership of the subways by such a company constitutes one of the chief difficulties in getting the electric companies to make use of the conduits already laid.

The *Evening Post* would have done better service to the public by confining its attack to the Subway Commission and refraining from an assault upon a particular method of distribution; but if it finds itself constrained to antagonize the alternating current system (which we trust is not the case) it would do well in future to submit the work of its reporters to some competent electrical engineer before printing it.

THE time is getting short for the Medico-Legal Society to complete its task of devising the proper method of executing capital offenders by electricity in accordance with the laws of the State of New York. We can not believe that the amiable doctors and lawyers of the society enjoy their labors, which we fear a thankless community fails to appreciate, and we can see no better way for them to discharge their obligation and acquit their conscience than the adoption of the suggestion of the ELECTRICAL ENGINEER, in October, viz., that the whole matter be turned over to Mr. Harold P. Brown. Let the Medico-Legal Society recommend to the legislature the creation of a new office, that of State Executioner, and make Mr. Brown incumbent for life. That gentleman may not be so "sarcastic" as his namesake of Calaveras—he certainly is not so "quiet"— but we have no doubt he will prove as efficient.

If successful in such a recommendation the society will not only have secured the selection of an uncommonly fit person for an important office, and have provided a career for an unappropriated genius, but will have relieved its special committee from further arduous and exhausting labors, such as attend scientific investigation and the preparation of reports like that presented at a recent meeting of the society. Give the job over to Mr. Brown and have done with it, Gentlemen.

THE retiring Mayor of New York, has signalized his administration of city affairs by the courageous exercise of his uncommon common sense, guided by his public spirit, in many practical reforms and improvements conducive to the public convenience and welfare, and now marks his last week of office by an official act that is not only typical of his practical methods, but timely and significant in respect to a prominent public question —that of city transit. In obtaining from the New York and Harlem Railroad Co. an agreement to put down better rails and improved track construction on a section of their line from the post-office, in consideration of his approval of the city ordinance granting permission to use electricity as motive power—together with the further promise of the company to reconstruct their entire line if the experimental section prove satisfactory in use after a fair trial—Mr. Hewitt has done the public a service of high value.

The prompt acquiescence of Mr. Vanderbilt and Mr. Depew in the Mayor's wishes is a very gratifying feature of the transaction. There is a refreshing novelty about such complaisance on the part of a large corporation.

A MYSTERIOUS reference to a so-called "corner in transformers," which is rumored to be about to come off between "two well-known companies," appears among the editorial notes of a recent number of the London *Electrical Review*. It is not difficult to identify one of the parties alluded to as the owners of the Paul Jablochkoff patent of 1877; nor does it require an excessive amount of Yankee 'cuteness to guess that the other is the so-called Grosvenor Gallery syndicate. It is furthermore possible to conjecture through a glass darkly, that the rolé of the traveler from Jerusalem to Jericho is cast for the Metropolitan Electric Supply Company, Limited. The overture it seems is now being played by the orchestra, but before the curtain rises, it may not be out of place to remark that the fun of a tiger-hunt sometimes depends on who does the hunting.

FOR some time past there have been many rumors and much talk of proceedings concerning a consolidation of the two largest incandescent electric light companies. Whatever truth there may be in such reports, it is not worth while to be impatient for the announcement of a result. The preliminaries of such amalgamations are frequently complicated and prolonged by an annoying difference of opinion on a question which once troubled a pair of mariners, who were trying to bring about a consolidation, but as the ballad tells us,

"They'd both be blowed if they'd either be stowed
In the other chap's hold, you see."

THE paper on "Six Years' Practical Experience with the Edison Chemical Meter," read before the American Institute of Electrical Engineers, December 18th, by Mr. W. J. Jenks—which we print in this issue, with the author's revision—will be found full of interest in electric light circles and to customers served from central stations.

We take the liberty of congratulating Mr. Jenks on the manner as well as the matter of his paper. Its value as a record of actual work is enhanced by its entertaining style.

THE committee on transportation of the National Electric Light Association, announce that by arrangement with the Trunk Line Association they have obtained a reduction in railroad fares of one-third for members attending the convention of the association at Chicago in February. The reduction will apply from points east of Niagara Falls, Buffalo, Salamanca, N. Y., Pittsburgh, Pa., Bellaire, O., Wheeling and Parkersburgh, W. Va.

OBSERVATIONS.

MR. THOS. D. LOCKWOOD must add another item to his chronology of "anticipations," electrical or otherwise. Here is an otherwise one from Thackeray's Pendennis, written in 1850: Chapter xviiii. "Nothing would satisfy Mr. Foker, but painting Mr. Buck's door vermilion, in which feat he was caught by the proctor."

* * *

MANY an intended shaft of wit fails of its mark because a reporter, a proof-reader, or an editor knows nothing of the bow strained to give it flight; and cannot, or will not spare five minutes in which to obtain the information; or because the archer himself does not take care to pick up and launch the identical arrow previously chosen for the purpose. In cases where the latter is the culprit, the punishment certainly fits the crime, for he always reads over his own production, and if it reads wrongly the iron enters his soul.

As the Holy Writ hath it, "Offences must needs come, but woe to him by whom the offence cometh."

Here is a specimen from an electrical book which was published in New York in 1886, and which is a most interesting one to read; on page 40—"*Ordinary iron telegraph wire has a resistance of about 18 ohms to a mile.*" On page 41; "*An ohm answers to the resistance offered by 460 feet of ordinary telegraph wire approximately.*"

Both statements cannot be true; and the student naturally wants to know which is, if either?

ARTICLES.

ELECTRIC MOTOR DIAGRAMS.

BY CHAS. L. CLARKE.

In an article entitled "Puissance et Rendement des Moteurs Électriques,"[1] Hospitalier clearly and forcibly explained, and illustrated diagrammatically, the relation which the ratio of counter electromotive force to direct electromotive force bears to the strength of current, to total energy consumed, to energy converted into heat and work, and to the ratio of work to total energy, the last being the expression for the efficiency of the motor. At the time of its publication the article in question attracted much attention and was particularly welcome to those whose efforts were directed to the development of economical motors but who had not the mathematical training necessary to make use of the information in the form in which it was then available. The purpose of the present article is to extend Hospitalier's diagram and to include the important factors of speed, torque, strength of field, and resistance for plain shunt and series motors.

In order that the diagrams shall be mathematically exact, and also general in their application, it is necessary to assume :—

First, that the inductive value of the field varies as the strength of the field current. This is approximately the case when the field magnets are considerably below saturation.

Second, that the inductive value of the field is not altered by variation in the strength of current in the armature circuit.

Third, that the resistances of the armature or field circuits are not varied by change of temperature, or that any such variation is compensated by an adjustable resistance.

Fourth, that the direct electromotive force on the armature circuit is constant.

Fifth, that the field circuit of shunt motors is supplied from an independent generator of constant electromotive force.

From the theoretical diagrams a general idea of the principles governing the operation of motors can be obtained, and to those skilled in the art, the limitations, which must be applied to the theory, to adapt it to practical requirements, will be apparent.

In the diagrams, the horizontal scale represents the value of points on the horizontal line only. This line is the abscissa for all others, the value of the ordinates being given by the left-hand scale for full lines, and by the right-hand scale for dotted lines. The values being expressed in terms of their ratio to unity, the equations from which they are obtained are expressed in terms of the variables only.

SYMBOLS.—FOR BOTH SHUNT AND SERIES MOTORS.

NOTE.—In series motors, the "armature circuit," hereafter mentioned, includes the field circuit.

Direct electromotive force	E
Counter electromotive force	e
Active electromotive force	E^1
Current in armature circuit	C
Resistance of armature circuit	R
Total electrical energy consumed in armature circuit	W
Electrical energy in armature circuit converted into mechanical energy	w
Ratio of w to W	M
Electrical energy in armature circuit converted into heat	H
Speed of rotation of armature	S
Statical moment or torque on armature	T
Inductive value of the magnetic field upon the armature	F

1. *La Lumière Électrique*, 1880, vol. ii., page 305.

SYMBOLS.—FOR SHUNT MOTORS ONLY.

NOTE.—The following symbols apply to the field circuit of shunt dynamos only, it being independent of the armature circuit.

Resistance of field circuit	r
Current in field circuit	c
Electrical energy consumed in field circuit, all of which is converted into heat	h

The mechanical work performed by the motor is $w = e \times C = T \times S$. Of this a certain amount is consumed in overcoming the friction of bearings, resistance of the air, the drag due to Foucault currents, etc. The balance is available for useful work.

SHUNT MOTORS.

CASE I.—CONSTANT ARMATURE CIRCUIT RESISTANCE AND FIELD. (DIAGRAM A.)

The value of e (line F) is expressed in terms of its ratio to E, the latter being equal to unity, or 100 per cent.

$E^1 = E - e$ is represented by line C.

$C = \frac{E^1}{R}$ " " C.

$W = E \times C$ " " C.

$w = e \times C$ " " E.

$M = \frac{w}{W} = \frac{e}{E}$ is represented by line B.

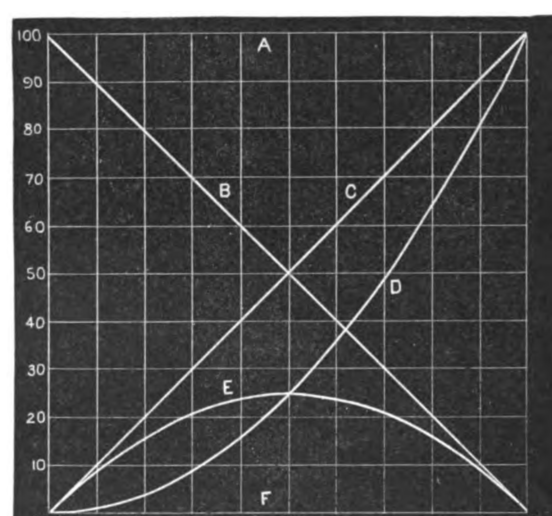
$H = E^1 \times C$ " " D.

The value of F being constant, e must vary as S, therefore,

$S = e$ is represented by line B.

$T = \frac{w}{S} = F \times C$ is represented by line C.

F and E being constant, r, c, h, are necessarily constant and all are represented (as is also the constant R) by line A.



A

It will be observed that when e is equal to E, S and M have their maximum values and that E^1, C, T, W, H and w are each equal to zero. In practice, this is an impossible condition, inasmuch as the friction of the bearings alone requires that T shall be finite. When e is 50 per cent. of E, w has its maximum value and is equal to H. H has one-quarter and E^1, C, W, T, M and S, one-half of their theoretical maximum values. When e equals zero, E^1, C, W, T and H have their maximum values, and M and S are equal to zero. This condition is represented in practice when the armature is prevented from turning.

Economical motors should be so proportioned that, when the value of e is at least as high as 95 per cent. of E, the speed is safe and practical for continuous work. If the load were entirely taken from such a motor, the speed could increase

but five per cent. Therefore a shunt motor cannot "run away," and when the load varies but little from its normal amount, is practically self-regulating.

CASE II.—CONSTANT ARMATURE CIRCUIT RESISTANCE AND SPEED. (DIAGRAM B.)

As in case i., e is expressed in terms of its ratio to E by line F. E, S and R are constant and represented by line A.

The values of the following factors are the same as in case i.

E^1, C, W, are represented by line C.
w is represented by line E.
M " " B.
H " " D.

S being constant, e must vary as F, therefore,

$F = e$ is represented by line B.

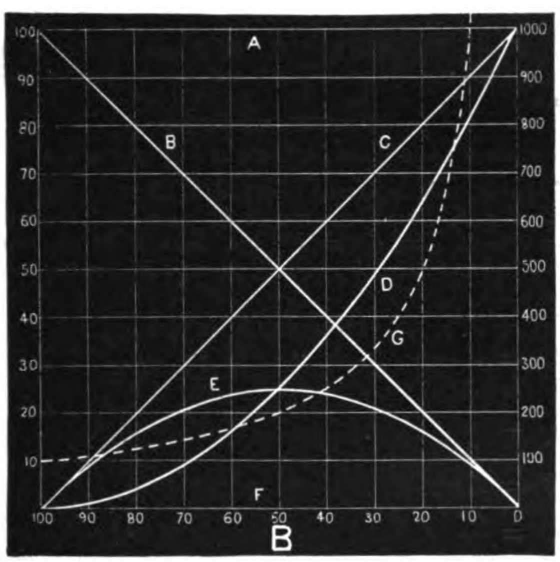
$T = \dfrac{w}{S}$ " " E.

F varies as c, therefore,

$c = F$ is represented by line B.
$h = E \times c$ " " B.

With E constant, F varies inversely as r, therefore,

$r = \dfrac{1}{F}$ is represented by line G.



It will be noted that T varies as w, and that F varies as e. If the load increases, the strength of the field must be diminished for all values of e greater than 50 per cent. of E, and increased for all values of e less than 50 per cent. of E.

In practice T must be finite (case i.), therefore e equal to E is an impossible condition, because T must then equal zero. For the same reason e cannot be equal to zero. A definite strength of field is necessary to start the motor and its speed is maintained constant by field regulation.

CASE III.—CONSTANT ARMATURE CIRCUIT RESISTANCE AND TORQUE. (DIAGRAM C.)

As in cases i. and ii., e is represented in terms of its ratio to E by line F.

E, T and R being constant are represented by line A.

E^1, C, W, w, M, H, have the same values and are represented by the same lines as in previous cases.

$S = \dfrac{w}{T}$ is represented by line E.

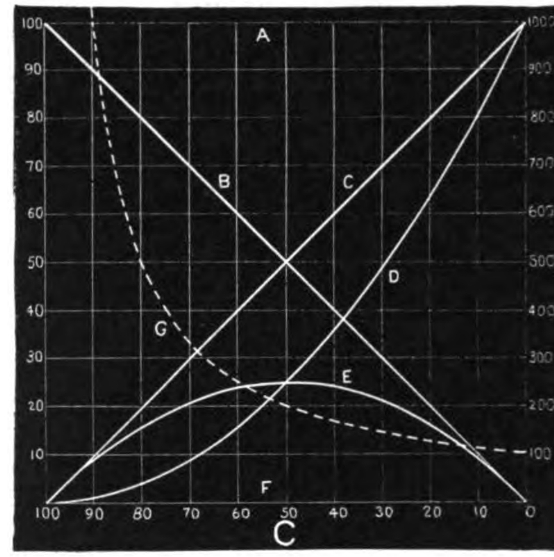
$F = \dfrac{T}{C}$ " " G.

$c = F$ " " G.

$h = E \times c$ " " G.

$r = \dfrac{1}{F}$ " " C.

The load is constant, and if the speed is to be increased, the field must be diminished for all values of e greater than 50 per cent. of E, and increased for all values of e less than



50 per cent. of E. e cannot equal E because the field must be of infinite strength. e will equal zero when the armature is just on the point of stopping. The speed is varied by field regulation.

CASE IV.—CONSTANT SPEED AND FIELD. (DIAGRAM D.)

E, F and S being constant, it follows that e, E^1, r, c and h must be constant, all of which are represented by line A.

It is also evident that the torque, and therefore work of motor, can be changed only by varying the current in the armature circuit. Let the variation of C be represented by the line D, then

$R = \dfrac{E^1}{C}$ is represented by line C.

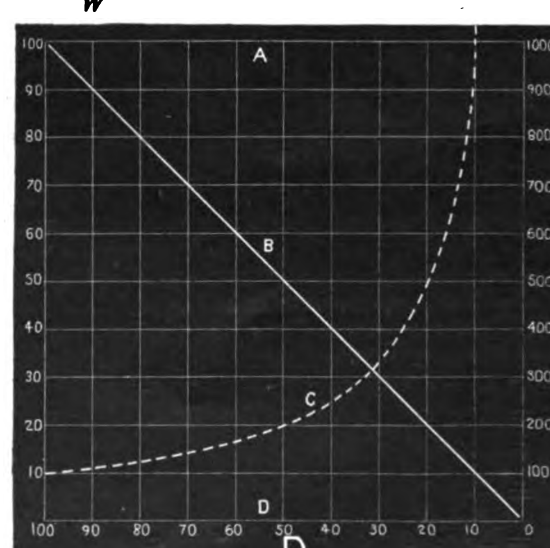
$W = E \times C$ " " B.

$w = e \times C$ " " B.

$H = E^1 \times C$ " " B.

$T = F \times C$ " " B.

$M = \dfrac{w}{W}$ " " A.



Note that W, w, H and T vary as e, and that M is constant.

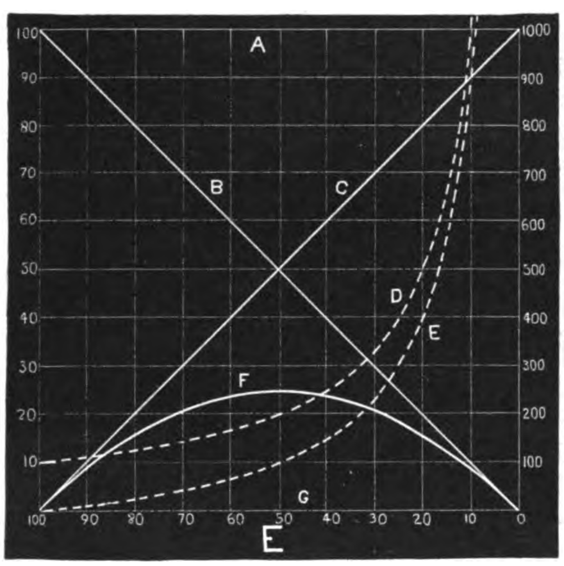
C cannot equal zero because R must be infinite and T equal zero, two impossible conditions. The speed is maintained constant by regulation of the armature circuit resistance.

CASE V.—CONSTANT SPEED AND TORQUE. (DIAGRAM E.)

e is represented in terms of its ratio to E by line G.
E, S and T are represented by line A.
S and T being constant, w is necessarily constant and is also represented by line A.
$E^1 = E - e$ is represented by line C.
S being constant, e must vary as F, therefore,

$F = e$ is represented by line B.

$C = \frac{T}{F}$	"	"	D.
$R = \frac{E^1}{C}$	"	"	F.
$W = E \times C$	"	"	F.
$H = E^1 \times C$	"	"	E.
$M = \frac{w}{W}$	"	"	B.
$c = F$	"	"	B.
$h = E \times c$	"	"	B.
$r = \frac{1}{F}$	"	"	D.



e cannot equal E or zero, because R must also equal zero, which is impossible. The constant speed under constant load is maintained by both field regulation and regulation of the armature circuit resistance. This case has no practical application.

CASE VI.—CONSTANT TORQUE AND FIELD. (SEE DIAGRAM F.)

e is represented in terms of its ratio to E by line D.
E, F and T are represented by line A.
F and T being constant, C must also be constant and is also represented by line A.

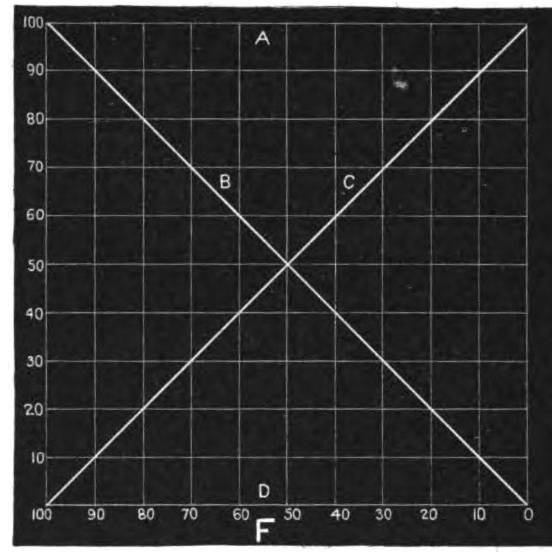
$E^1 = E - e$ is represented by line C.

$W = E \times C$	"	"	A.
$w = e \times C$	"	"	B.
$M = \frac{w}{W}$	"	"	B.
$H = E^1 \times C$	"	"	C.
$R = \frac{E^1}{C}$	"	"	C.

T being constant, w must vary as S, therefore,
$S = w$ is represented by line B.

F being constant, r, c and h must be constant, and are represented by line A.

Note that the speed with constant load and field is varied by regulating the resistance of the armature circuit only.



In practice e cannot equal E, because R must equal zero. e will equal zero when the armature is just on the point of stopping.

If F, S and T; F, S and R; F, T and R; or S, T and R are constant in shunt motors, all other factors will be constant.

SERIES MOTORS.

CASE VII.—CONSTANT TORQUE. (DIAGRAM F.)

e is represented in terms of its ratio to E by line D.
$T = C \times F$. In a series motor F varies as C, therefore, $F = C$ and $T = C^2 = F^2$, but since T is constant, C and F are constant, and C, F, T, and E are represented by line A.

$W = E \times C$ is represented by line A.			
$E^1 = E - e$	"	"	C.
$w = e \times C$	"	"	B.
$M = \frac{w}{W}$	"	"	B.
$H = E^1 \times C$	"	"	C.
$R = \frac{E^1}{C}$	"	"	C.
$S = \frac{w}{T}$	"	"	B.

The speed with constant load is varied by regulating the resistance of the circuit. e cannot equal E, because R must equal zero, which is practically impossible. e will equal zero when the armature is just on the point of stopping.

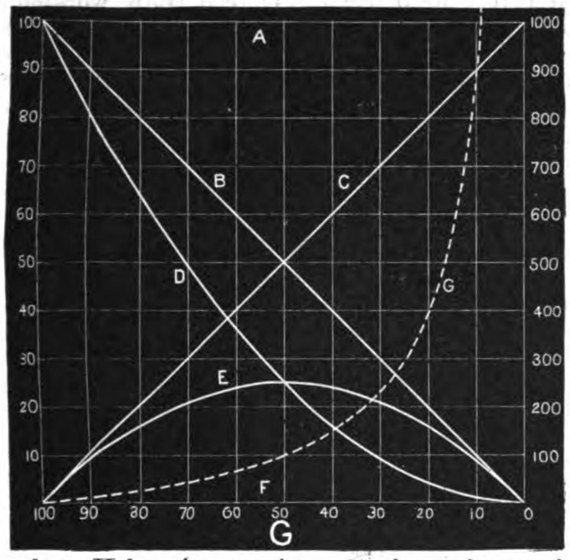
CASE VIII.—CONSTANT SPEED. (DIAGRAM G.)

e is represented in terms of its ratio to E by line F.
E and S are represented by line A.
$E^1 = E - e$ is " " C.
S being constant, e varies as F, therefore,

$F = e$ is represented by line B.

$C = F$	is represented by line B.		
$W = E \times C$	"	"	B.
$w = e \times C$	"	"	D.
$M = \frac{w}{W}$	"	"	B.
$H = E^1 \times C$	"	"	E.
$R = \frac{E^1}{C}$	"	"	G.
$T = \frac{w}{S}$	"	"	D.

The speed is maintained constant, under varying load, by regulating the resistance of the circuit. The field and torque increase and decrease together but not in direct ratio.



Note that H has its maximum value when e is 50 per cent. of E, and that when e is greater than 50 per cent. of E, H diminishes as the load increases.

e cannot equal E because R must equal zero. e cannot equal zero because R must be infinite.

CASE IX.—CONSTANT RESISTANCE. (DIAGRAM H.)

e is represented in terms of its ratio to E by line F.

E and R are represented by line A.

$E^1 = E - e$ is " " C.

R being constant, C and therefore F will vary as E^1, therefore $C = F = E^1$, and C and F are represented by line C.

$W = E \times C$ is represented by line C.

$w = e \times C$ " " E.

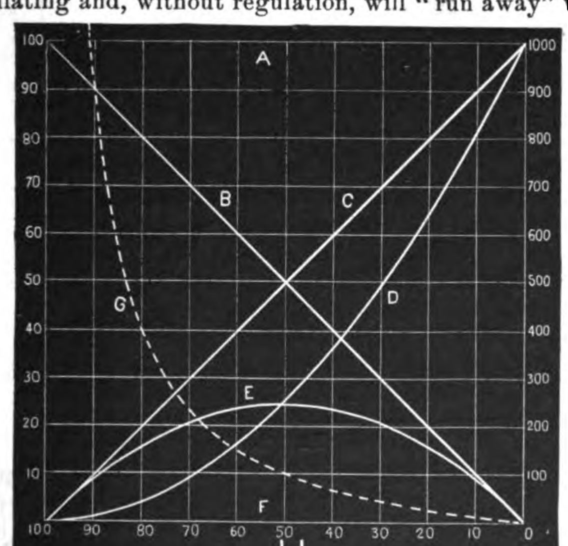
$M = \frac{w}{W}$ " " B.

$H = E^1 \times C$ " " D.

$T = F \times C$ " " D.

$S = \frac{w}{T}$ " " G.

Note that with constant resistance the speed becomes infinite when load equals zero. A series motor is not self-regulating and, without regulation, will "run away" without load. e cannot equal E, because T must equal zero. e will equal zero when the armature is just on the point of stopping.



CASE X.—CONSTANT FIELD.

If E is constant, C must be constant. It necessarily follows that all other factors will be constant. This is based upon the assumption already made that F varies as C.

If S and T, S and R, or T and R are constant in series motors, all other factors will be constant.

If the field magnets of series motors are saturated so that it may be assumed that the inductive value of the field is constant for all variations in the strength of current, then cases vii., viii., and ix. are represented by cases vi., iv. and i., respectively, omitting, of course, any consideration of the factors r, c, h.

SIX YEARS' PRACTICAL EXPERIENCE WITH THE EDISON CHEMICAL METER.[1]

BY W. J. JENKS.

"MEASURE FOR MEASURE" has ever been the underlying principle of the trade of the world. The mess of pottage for which Esau bartered his birthright was as truly in his eyes a recompense for the distinction and the patrimony with which he parted, as the property and the necessaries of life which we acquire are in our view an equivalent for the gold and silver which we pass from hand to hand in every-day exchange.

If we start out in life with the notion, so fondly cherished some time or other by every human heart, of getting something for nothing, we shall speedily realize the truth of what somebody has happily expressed in verse :—

> The motto of the world is "give and take,"
> It gives you favors, out of sheer good will;
> But unless speedy recompense you make,
> You'll find yourself presented with its bill.

We are not in business matters long contented with any system of guess-work as to what the amount of this bill ought to be. Where values cannot be measured, we demand averages based upon long experience. Where it is possible to measure goods delivered, the ingenuity of man is untiring until some means is found adapted to the uses of all the traders of the world. It is only so far as we can draw from nature's limitless supply of necessaries and blessings "without money and without price" that we fail to find in these days a meter check upon our consumption. As long as people live in civilized communities, water and artificial light will represent somebody's labor, and as they come to be more and more generally used, they must be more and more accurately measured.

Perhaps it has never occurred to many of us that about the only system of measurement that has ever quite satisfied mankind is the method or device by which we reckon the passage of time, which doesn't cost us anything. We look with suspicion on the scales of the butcher, and we don't believe the milkman's quart is more than two-thirds as large as it was years ago, though the price has advanced several per cent. When we buy dry goods we speculate on whether it isn't best to redetermine the length of a pendulum that will beat seconds at the level of the sea, or establish a new yard on the metric basis, after we measure the distance from the equator to the poles again. We know by the ticking of the water-meter that it is away off any standard, and last and oftenest we anathematize the gas meter and the man that reads it as being alike unsanctified.

Now the electric current meter is a baby yet, but it is very likely to be considered by the great majority of mankind as a direct descendant of the gas meter—"a chip of the old block." Unfortunately we cannot record directly the light or power really delivered from any source, and an approximation to such a record through the measurement of the quantity of energy supplied, is our only practical alternative. The method which we shall examine to-night,

1. Read before the American Institute of Electrical Engineers, New York, December 18th, 1888.

is thus far the only commercially successful means of measuring the energy delivered to electric lamps or motors. It is doubtless the first-born of a large family which will share in the stigma which the tribe of meters of all kinds has always borne. To show how far the stigma in this case is undeserved, and how much more accurately we can measure the mysterious intangible something, which we only know as a manifestation of energy and which we call electricity, than we can measure the palpable forms of matter which are apparent to all the senses, is the purpose of this paper.

In the approximation which we make to the measurement of the light, heat or power secured from gas, we have three variables: quality of gas, rate of flow, and form of burner or method of consumption. In electrical work we eliminate at once the first and one of the most uncertain of these variable factors, for there is no difference, so far as we can discover, in the quality or commercial value of electrical energy from different sources, unless we change the method or the rate of its delivery (as, for instance, send it out in intermittent or alternating impulses).

So in order to arrive at a price at which we may profitably sell light or power, we must know the electrical horse-power demanded by the translating device for a given result, that is the efficiency of the lamp or motor and the energy actually delivered, during the time of consumption. The work done or heat generated, which bears a definite relation (in a given type of lamp or motor) to the light or power produced, is expressed in three factors—pressure, current flow, and time; and the product of these, joules, or units of work accomplished in a given period, is what we desire to measure. In the Edison system the light of the lamp and the speed of the motor are based upon the supply at their terminals of a constant pressure, and as the Edison meter is in its relation to the resistance of the circuit practically at the lamp or the motor, it may for all commercial purposes be regarded as always acted upon by the constant standard of E. M. F. applied to the device which transforms the electricity to the useful energy of light or motion. Hence we really make this a joule meter, even while we drop the pressure which is a constant, and make it a measurer of current and time, or a coulomb meter. Its construction is based upon the fact that a given ampere flow will deposit a given weight of metal per second, and so knowing the weight of zinc deposited on a plate, it is easy to calculate the number of ampere seconds. In practice we take the hourly deposit (1224 milligrammes of zinc by one ampere), and knowing the fraction of an ampere required for the standard lamp, we can readily arrive at the lamp hours for which the customer should be charged. It is now becoming common to charge so much for an ampere hour, and sometimes the price is the same whether supplied to lamps or motors, which are thus often included within the registration of one meter.

It is in a comprehensive system of house to house supply, where every unit of light or power is made separately controllable, that the necessity for such a meter appears most vital.

The records of the patent offices of almost all the civilized countries of the world bear witness to the fact that the method of connecting lamps, motors or similar translating devices in multiple arc (the only commercial method of attaining this individual control of current actuated by safe potentials) was original with Mr. Edison. But beyond this there is no question that we owe to him the first comprehensive conception of that form of multiple arc distribution which by combining a low resistance armature, a feeder system of transmission, and a high resistance lamp and motor, has made it possible for us to secure at all lamps and motors a marvellously close approximation to uniformity of pressure, and the expenditure of the largest economical percentage of the initial pressure in overcoming the resistance of the carbon filament, or the counter-electro motive force of the motor armature, and thereby producing the greatest amount of useful work.

To Mr. Edison's view each detail of such a complete system appeared full of importance, and so we find him, almost before he had a commercial lamp, working on a meter by which each customer's consumption could be accurately determined, and which could be placed on his premises and inspected at such intervals as experience had shown were reasonable in the supply of the other measurable quantities, gas and water. He foresaw that it must not only be accurate, but cheap and durable. In his study of the subject he applied several principles of motion and registration, tried a great number of experiments with each, and secured several patents. Among them are the following:—

Fundamental electric motor meter.—Patent 242,901. Application filed March 3d, 1881. Figure 1 shows an old example of a large class of meter inventions in which some kind of an electric motor driven either by part or all

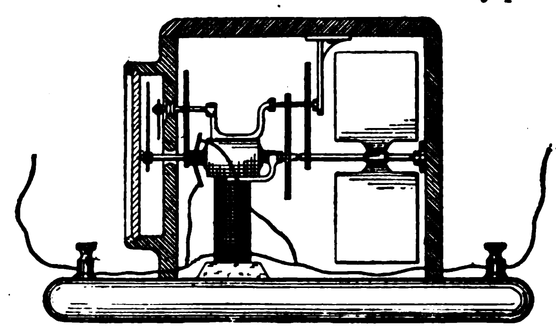


FIG. 1.

of the current to be measured, is employed to overcome a fluid friction, but the claims cover broadly the combination of a circuit, motor, fan, or other definite loading, and registering apparatus.

Figure 2 shows another form of electric motor meter. Patent No. 370,123. Applied for April 17th, 1883. The form of motor used is a development of "Sturgeon's wheel," the wheel being transformed into a cylinder surrounding one pole of the magnet, itself being surrounded by the other pole. In this meter the indefinite friction is reduced to a very small factor, brushes are replaced by mercury contacts, and a very compact and simple form is possible. Probably if mercury did not have such a

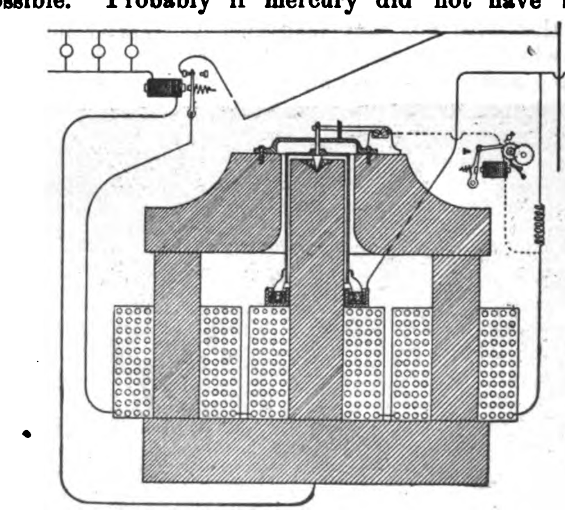


FIG. 2.

chronic disability to behave itself in practical continuous work, and if it really possessed the ideal character of a liquid which it commonly gets credit for, we would have seen this meter put into practical use by some one of the many inventors who have given it attention. This patent covers, among other things, the placing of the inductive portion in the direct circuit and the fields in multiple arc

therewith. A magnet in the main circuit closes the field circuit whenever the first lamp is attached, thus stopping the motor whenever the current flow is arrested.

Galvanometer recorder.—Patent 307,030. Application filed Oct. 10th, 1883. Figure 3. This covers broadly a multiple arc circuit, a galvanometer in the main line, a circuit

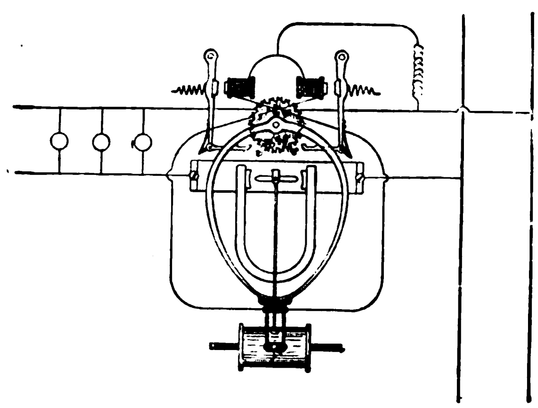


FIG. 3.

controlled by the needle, electrically operated apparatus in this circuit, and indicating or registering devices. Preference is given to a stylus recorder, the diagram made to be measured by a planimeter.

Recording electro-mechanical meter.—No. 293,435. Applied for August 14th, 1882. Figure 4 shows a pivoted beam oscillated by electro-magnetic coils in the main or a

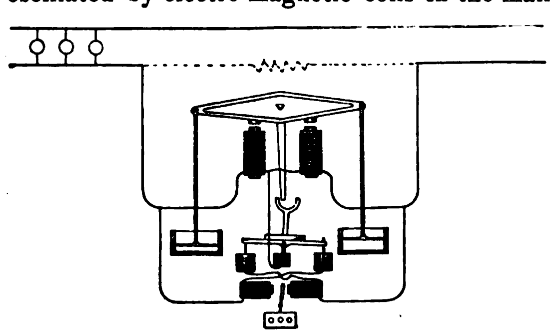


FIG. 4.

shunt circuit, the rapidity of motion (regulated by air dash-pots of large surface) being practically proportional to the strength of the current. The recording mechanism actuated by a local circuit operated by mercury contacts.

Fundamental electrolytic meter patent.—No. 251,545. Application filed March 20th, 1880. Figure 5 shows the electrolytic meter according to the first Edison patent. An electro-magnetic cutout is shown and claimed as part

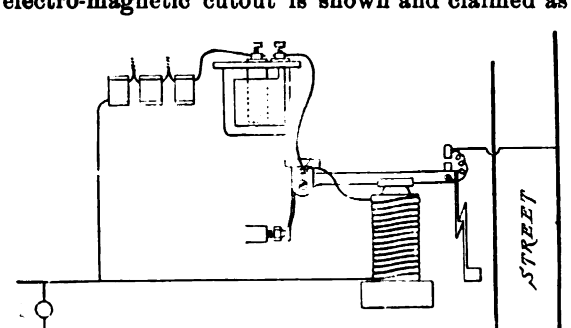


FIG. 5.

of the meter. The principal claim covers the use of an electrolytic cell placed in a shunt circuit, the resistances being so proportioned that a definite fraction of the current passes through the cell.

Recording electrolytic meter.—No. 304,082. Application filed August 14th, 1882. Figure 6. At the time of the Paris Exposition of 1881 the Edison meter was exhibited in the form of an automatically recording apparatus, two electrolytic cells being used, one plate of each suspended from the beam of a sensitive balance, the circuits being so arranged that one cell only is in circuit at a time and the direction of current in that cell is such that the electrolytic action will throw the balance out of equilibrium, cause the beam to "kick" and by that action throw the current to the other cell and register one on the counter. Whether this form was seriously intended for general use may be doubted,

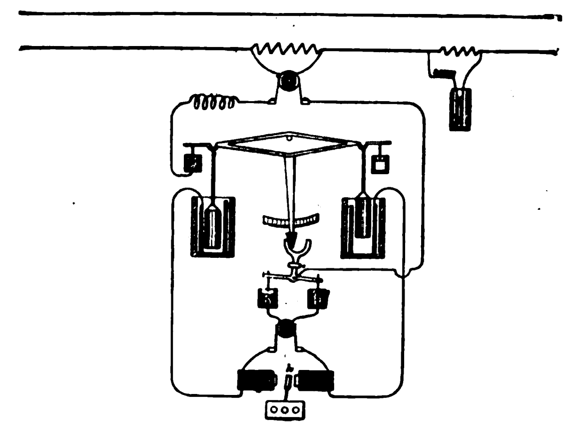


FIG. 6.

but it was very carefully worked up, several different forms patented, and it attracted a great deal of attention and well deserved admiration in its time. Figure 6 shows plainly the general form and the connections. The counter is operated electrically by the motion of the index of the balance; contacts are made in mercury cups; dash-pots regulate the motion; reversing commutators, operated by hand once a month, keep the transfer of copper from plate to plate from going always in one direction. A simple electrolytic cell is used as a check. This is probably significant of the inventor's lack of faith in mechanical meters, and is particularly interesting to look back upon, in the light of subsequent progress.

Revolving recording electrolytic meter.—(Still pending in the patent office.) Figure 7 shows an interesting modification of an integrating electrolytic meter, in which between two electrodes immersed in the electrolyte is placed a wheel or cylinder of the same metal, free to re-

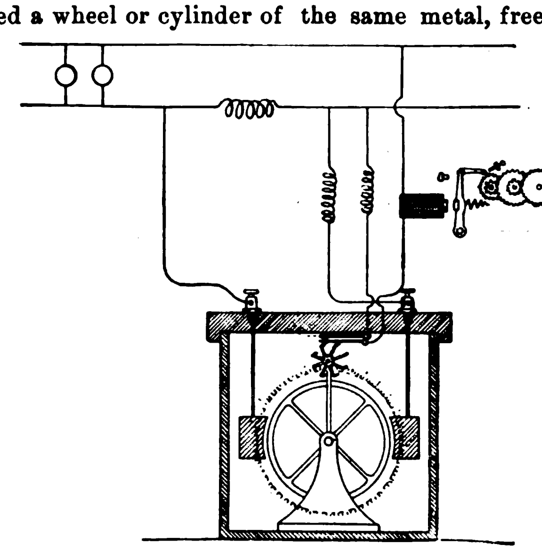


FIG. 7.

volve on its axis. It is apparent that if the wheel were perfectly balanced and delicately poised, the passage of a current would alter the balance, and it would revolve at a speed depending almost entirely on the friction of its bear-

ings. But if it were first caused to revolve at a definite rate for one-half a revolution, the lower limb moving in the same direction as the current, there would be a deposit and loss on opposite halves of the periphery, causing a variation of position of the centre of gravity around the point of support, causing the revolution to continue at the same rate for the same current or at a rate proportional to the current.

The diagram shows a dial scale for reading fractions of a turn and an electric counter recording complete revolutions.

Floating electrolytic cell.—Patent 248,565. Application filed December 15th, 1880. Figure 8 shows a eudiometer intended to decompose water, collect the mixed gases in a bell-glass, and when a definite quantity is evolved by the raising of the glass automatically cause recomposition (and consequent falling of the glass) by closing a circuit through a platinum coil which becomes heated thereby. This operation is to be repeated continuously

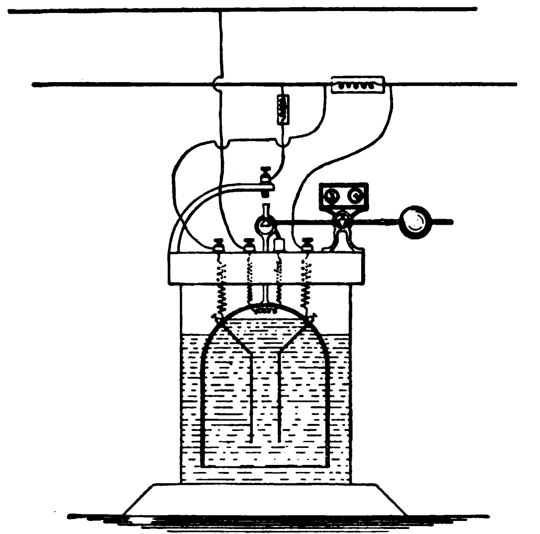


FIG. 8.

while the current is passing, a counter giving a record of the number of charges of gas exploded.

Among the difficulties of using such an apparatus are the comparatively high E. M. F. required, the energy wasted, and possibly like the nitro-glycerine engine, "the necessity of providing a new machine after each explosion." A very similar apparatus has been recently proposed as a laboratory standard for current measurement.

Automatic temperature regulator.—No. 251,558. Filed August 30th, 1881. This patent, illustrated in figure 9, covers important features of the Edison meter of to-day. Briefly, these are: (1) the resistance E acting as a

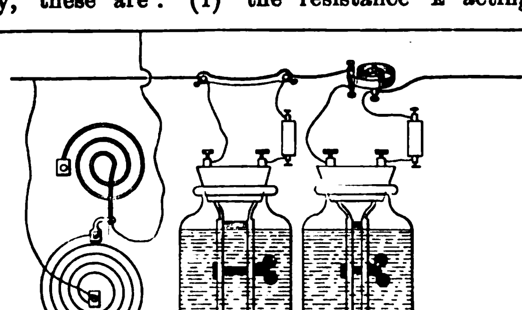


FIG. 9.

source of heat to prevent freezing of the liquid in the bottles; (2) the thermostat G completing circuit through E at the proper degree of temperature; (3) distance pieces for holding the electrodes a fixed distance apart.

Fundamental temperature regulation patent.—No. 265,-774. Application filed November 11th, 1881. Figure 10 illustrates a method of generating heat by the action of a thermostat energizing an electro-magnet controlling a valve, which being opened permits water to flow upon quick lime. This is one of the methods illustrative of the broad idea of "causing a fall in the temperature to set in action agencies for generating heat," and thus maintaining automatic temperature regulation in an electrolytic cell.

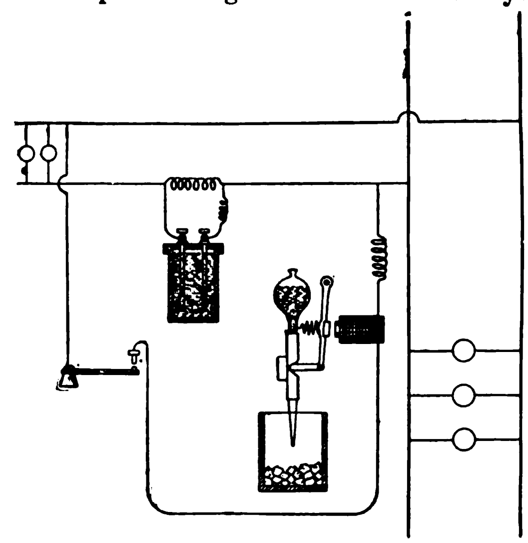


FIG. 10.

Another method here described is the one now practiced, the closing of "a circuit to an electric lamp placed in proximity to the cell." On the same date of this application Mr. Edison filed Patent No. 281,352, describing one of the most vital features of the practical apparatus, namely, amalgamated zinc electrodes in a solution of sulphate of zinc. This overcame the disadvantages of copper plates, which had formerly discouraged the inventor.

Compensating coils in electrolytic meters.—No. 251,557. Applied for May 27th, 1881. Figure 11 illustrates certain minor claims of details, some of which apply to the Edison meter of to-day, and one feature without which probably no electrolytic meter would be practical, the "compensating spool" having a + temperature coefficient to balance the — coefficient of the bottle resistance. This patent

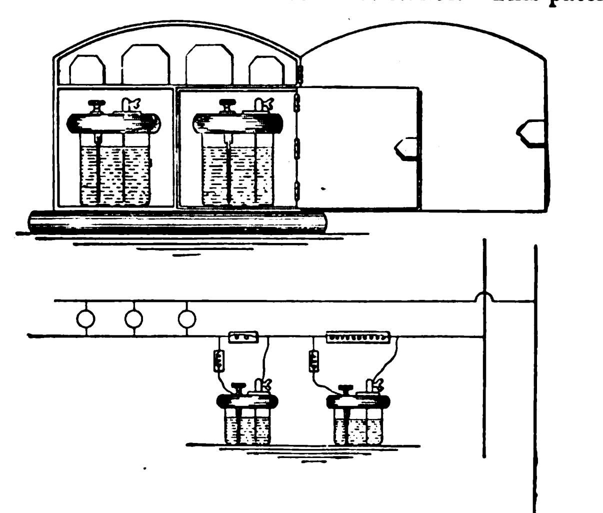


FIG. 11.

rlso covers the use of two cells, depositing with unequal rapidity.

The original plan involves, of course, only a two-wire meter. This was first made with a separate resistance for each bottle, one of them being intended to register a

month's consumption, the other three months. It was also proposed that the two compartments have separate keys, the inspector of the three months bottle thus having a private check on the three readings taken in the same time from the other side. It was soon found preferable to weigh both sets of plates together, particularly as inexperience in the manipulation gave rise to errors against which the duplicate records formed a check of great usefulness. This duplication has been found unnecessary in the smaller sizes.

The student of the meter question may find interesting modifications of these general principles in patents 240,678, 281,352, and others.

These sketches and the patents enumerated convey a faint idea of the months of patient analysis, the multitude of experiments and the scores of models and drawings which may be found described in Mr. Edison's note books, many a page written by his own hand years before the electrical fraternity conceived of the importance of these devices for which the world now loudly calls. The electrolytic principle was finally determined upon, the details perfected, and more than six years ago the first devices were placed in the offices and stores of the first customers of the Pearl st. station in this city, the first station in the world to distribute current for incandescent lamps by a comprehensive system of conductors buried underground like gas pipes. The experiments thus made were so exhaustive and thorough in their character, that the meter then designed is substantially the one in use to-day in

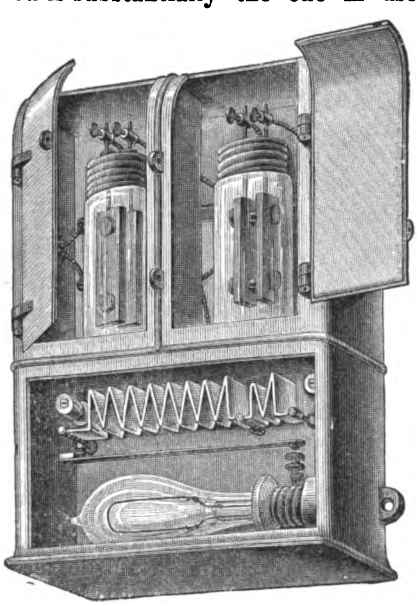


FIG. 12.—Old form of two-wire meter.

numerous stations throughout the United States and several stations in foreign countries. The Edison company has tested every form of direct current meter thus far found in any degree practicable without discussing (as vital) the question of economy either in first cost or operation, and has no knowledge of any other form which has been found to be as accurate under all working conditions, and as reliable when submitted to that tribunal before which so many carefully constructed electrical devices fail,—the test of time. The Edison meter is also cheap, but this is of less vital importance. All other forms appear to be commercially impracticable. Some have inherent de fects, caused by variations of permanent magnetism. Some are too large to be of any value for commercial use, and they are almost, without exception, too costly and delicate for practical service, or too wasteful of the energy they demand for their operation. We have abundant evidence of the justice of these statements when we remember that out of the many meters thus far proposed, there is not another which has come into anything like extended use.

The record which we can quote is therefore the only one from which any conclusions can be drawn as to future practice in this direction.

We shall be better prepared to appreciate the results obtained after glancing at the distinctive features of the meter as at present constructed.

Figure 12 shows, in an iron case, the form of meter placed at the time of starting the first district station, September 4th, 1882. The division in the german-silver shunt resistance for the long and short period bottles has given place to a method of connecting both to the same terminals. The flexible connections have been superseded by the spring clips, and in the three-wire meters two shunt resistances are placed, as in figure 13.

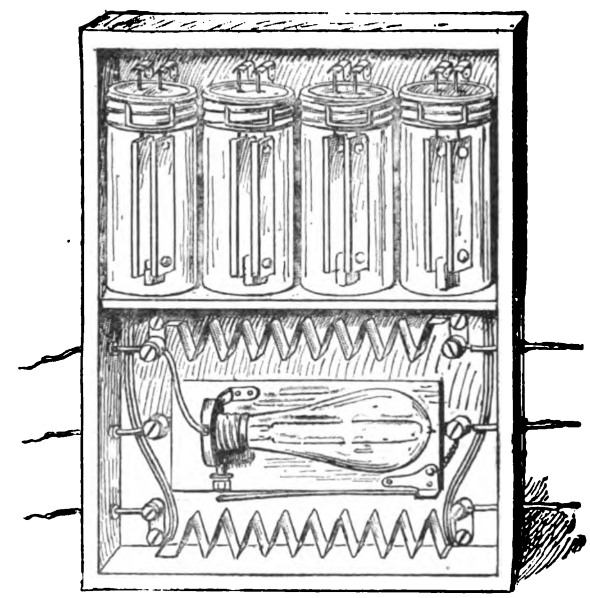


FIG. 13.—Three-wire meter, open.

Stripped of all complications, the connections of these types are clearly shown in the diagram, figure 14.

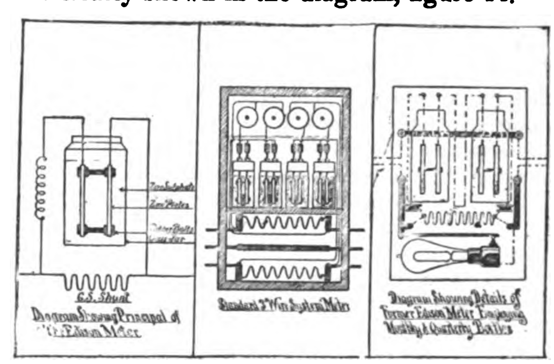


FIG. 14.

The meter case is made of well-seasoned hard wood specially prepared to expel air and prevent warping, and to maintain high insulation ; the door of heavy sheet iron properly lettered and numbered. This is held closed by a metallic button turning upon a small post, both passing through a vertical opening. The wire of a lead seal is passed through the button.

The conductors enter and leave the meters through holes in the side or bottom, about two or three inches apart.

The thermostat is required for all meters situated in locations where the solution is likely to freeze. It is furnished as an extra attachment and may be inserted in any size meter, and to it is attached a small contact point connected with a lamp socket. Into this socket is screwed a lamp, and when the temperature in the meter falls below a certain point it will cause the thermo strip to curve up, bringing the two contact points together, closing a circuit

through the lamp and heating the interior space. As the temperature returns to normal the strip straightens and the lamp is cut out. The adjusting screw in one complete revolution changes the elevation of the contact point $\frac{1}{16}$th of an inch, and being made with a six-sided head (numbered), $\frac{1}{6}$th of a turn will change the absolute temperature standard of contact about two degrees Fahrenheit. Thus the adjustment may be made sufficiently close.

The cells are partially filled with a 10 per cent. zinc sulphate solution, no special effort being made to render them air-tight, except so far as to prevent evaporation. In these the zinc plates are supported by ebonite distance pieces, screws and nuts, and connected by copper rods with spring clips fixed in the top of the space.

The resistance in the main circuit is of german silver, of the quality used by Elliot in his bridges, and so proportioned as to allow $\frac{1}{975}$th of the current to pass through the cell and its compensating spool.

The small portion of current passing through the bottle removes from one plate and deposits upon the other metallic zinc, which when its weight is ascertained determines the current transmitted.

The two-wire meters authorized to be used with the three-wire system, are of two sizes only, five and ten amperes capacity, respectively. Anything larger than five amperes may be preferably divided to balance the two sides and hence they are made of five amperes each side; capacity, 20 of the present 16 c. p. lamps; 10 amperes, 40 lamps; 20 amperes, 80 lamps; 40 amperes, 160 lamps; 80 amperes, 320 lamps.

This will be made more clear by a

TABLE OF SIZE AND CAPACITY OF METERS.

Meter No.	Maximum ampere capacity.	
0	5	2-wire meter for 5 amperes.
½	10	" " " 10 "
1	10	3-wire meter for 5 amp. on each side.
2	20	" " " 10 " "
4	40	" " " 20 " "
8	80	" " " 40 " "
16	160	" " " 80 " "

In selecting the proper size of meters for certain customers it is borne in mind that a meter plate has, like a storage battery, a somewhat definite maximum capacity in ampere-hours per month. The standard found most desirable is 150 milligrammes deposit per month per ampere of nominal capacity.

The normal capability is therefore understood to be restricted to an average work of one or two hours per day at this maximum load, which corresponds with practical work. If steady work is to be done for an average of three to four hours daily, the load should be about 20 per cent. less; if from five to six hours, about 25 per cent. farther reduction should be made to determine the proper limit for a given plate.

The meter is, in practice, placed in all sorts of positions. The general instructions simply provide that it shall be kept clean and dry, inside the service fusible cut-out, and easy of access.

The initial preparation of plates consists simply in thorough cleaning, covering the top and about an inch of the rod with a coat of asphalt varnish, amalgamating and drying (three coats when new), weighing and tagging of the positive plate, and placing in the solution.

When removed the plate is re-weighed, and where two bottles are used their weights are compared by the meter man and his record sent to the book-keeper or superintendent.

The loss in milligrammes sustained by the positive plates is then multiplied by the meter constant which gives the bill in dollars and cents. This constant is found as follows:—

Let \$ equal price of one standard lamp hour.

C equal ampere capacity of standard lamp.

Then current through the bottle equals $\frac{C}{975}$

As 1224 milligrammes (of zinc) is represented by one ampere-hour, one standard lamp hour is equivalent to $\frac{1224\ C}{975}$ milligrammes, at the price \$. Hence the price for current which has removed one milligramme of zinc will be :—

$$\frac{\$}{\frac{1224\ C}{975}} \text{ equals } \frac{\$ \times 975}{1224\ C} \text{ equals constant.}$$

Each consumer has a meter upon his own premises, and his bill is made out and payment required upon what the meter shows. To measure the current by means of a meter, and to do so with sufficient exactness to support a bill, the payment of which was to be insisted upon, at first seemed to many of the customers of our various companies an impossibility, and they accordingly resorted to various devices for the purpose of testing the accuracy of the measurements themselves. The most noteworthy of these, for the reason that it affords a simple and effective check, was to keep a record of the hours each lamp was in use, and by multiplying this number by the given rate of a sixteen-candle lamp per hour, to determine what the amount of the bill ought to be. There have been many instances where, in order to satisfy customers that the meters were reliable, we have taken their record at the end of a given time, during which the customer has kept an account of his lamp hours, and have presented bills upon what the meters showed, that the customer might check the amount of his bill by this simple rule.

It has been argued that the Edison chemical meter, in its best estate, is open to several very serious objections :—

1. The necessity of the expense attending the removal and replacement of the bottles, usually at monthly intervals, and the complete disconnecting and weighing of their plates. So far from being a detriment, this is seen to be in the light of practice a positive advantage. A gas meter is adjusted once for all, and once placed is inspected only at long intervals, or when strongly suspected of inaccuracy, while the Edison meter receives thorough inspection and radical readjustment every month. The sources of error lie almost entirely within the bottle, and are thus speedily corrected.

2. The necessity of employing what objectors are pleased to term a "chemist" as a meter man. In the early history of any art, until the conditions of practice become thumb rules, the manipulator of an important device should be a man of intelligence and some originality of ideas. After a time the work becomes simply a matter of routine, and the occasional oversight of the manager or other official will detect any irregularities. Thus it has been with this branch of our work. The most of our meter men are young, and receive only moderate pay, as the statement of cost of operation elsewhere given, conclusively shows. Accuracy and caretaking in matters of detail are the prime requirements. The work has been greatly simplified by arrangements with Mr. Edison, by which electrolytic zinc plates, standard zinc sulphate solution in carboys (or salt, if preferred), distilled mercury and four simple reagents, for the testing of water for solution by such companies as prefer to prepare it themselves, as a matter of convenience or economy. These reagents are :—

(1) Ammonia water.
(2) Ammonia sulphide.
(3) Nitrate of silver, and
(4) Sulph. cyanide of potash,

a few drops or a small crystal of each, as the case may be, to be added to separate portions of water. Any meter

man can thus make the four simple tests, which, by a precipitate or by cloudy coloration, will show the water to be unfit for use.

Ordinarily, ice water is available, and where this fails, a simple apparatus for condensing and distilling, costing $25, is sometimes desirable.

Sources of error.—This brings us to the consideration of the real importance of the sources of error. Nothing that man has made is free from some of these drawbacks to accuracy, but when we except those mechanical imperfections common to all electro-mechanical devices, it is surprising how few appear which play any important part in the result, and how far these few are neutralized. In order to point the application of the few facts and diagrams to be shown, let us refer briefly to the criticisms made on this much-misrepresented but important friend of the Edison manager.

From the English *Electrician* of December 16, 1887 :—

"Edison calculates the total consumption of current by passing a known (or supposed known), fraction of the total current through the meter, and the energy supplied is calculated on the assumption that the difference of potential is constant throughout the circuit. This assumption is, of course, only approximately correct."

From the same journal, December 30, 1887 :—

"In the third edition of Sir David Salomons' work on the 'Management of Accumulators,' the author (on page 105), gives the following definition of Edison's meter : 'A thing of the past, depending upon the deposit of some metal.' We are, unfortunately, a little doubtful as to the immediate accuracy of the first part of this description, inasmuch as we are under the impression that this apparatus is still extensively employed by the Edison company of the United States; but in the light of the statements alluded to above, there can be but little doubt that Sir David's description will, sooner or later, be perfectly accurate. As to the 'deposit of some metal,' which appears at present somewhat erratic, we suppose the balance is made up on the settlement of the account. But if these accounts have any foundation, it is perfectly clear that the error is entirely against the company. As we recently had occasion to remark in our articles on the Brighton installation, the Edison plan, by which a fraction only of the current supplied is measured, can be accepted as little better than a makeshift at the best."

One more quotation (from the *Electrical World*, of a little more than a year ago—Oct. 22, 1887,) of some remarks made at one of the meetings of this Institute. It is especially desirable to bear them in mind, as an illustration of the idea that a little knowledge and a great deal of theory on any subject is a dangerous thing in the light of actual experience :—

"There has been already a great deal of time and a large amount of money spent on electric meters for direct currents, and I do not think we have had any current meters of any value whatever.

"The electro-chemical system, in use by a very prominent company here, was put out with a great deal of confidence with the results to be obtained from it. I think any one looking at the principles involved would condemn it from the start. You are to take a small fraction of the total current, and a very small fraction indeed, and pass it through an electrolytic cell, the character of which varies from time to time, so that the resistance is never fixed, and pass the bulk of the current around a resistance which is practically fixed. The change in the resistance of the metal would be but a small proportion of the change in the resistance of the electrolyte. Now in such an instance as that you are measuring a very small fraction of the current passing, and whatever error you have are multiplying that error by the fraction. If you are measuring 1-1000 you are multiplying your error by 1000. Any one who has had much to do with electro-metallurgy knows that the cells are constantly changing; that to keep the deposit regular and uniform, to keep the resistance of the solution uniform, they must be constantly attended to. There is not an electro-plater in the country who does not once in a while go in and stir up his baths. Such an instrument is of no real value. We may, therefore, dismiss those instruments entirely from consideration, I think.

"If any one will take the record of the patent office on electric meters, he will see that there has been no small amount of time and thought and money spent on that question. Practically, we are in the same position we were before. We had nothing except the electro-chemical meter, which, as I say, I consider entirely worthless."

The lack of information on this subject, thus illustrated, will be seen more clearly by an analysis of the actual value of the sources of error.

Oxidation.—In the hands of an inexperienced person almost any method or device, good and reliable in itself, may be misapplied so as to gain an unenviable reputation. An Edison meter cell may be so manipulated as to measure almost any resistance and vary between wide limits. A few practical rules have, however, been applied, and the bugbear which has so disturbed the visions of those who have looked at the matter from a theoretical standpoint only has disappeared. In other words, we are able to reduce practically to nothing this error, and it therefore appears in the results only as a slightly disturbing element at the lower end of the deposit curve, and always against the company.

The german-silver shunt.—The extract I have read specifies quite distinctly the slight error introduced by the change of resistance of the german-silver shunt with temperature variations. For each 25 degrees Centigrade or 45 degrees Fahrenheit this variation is but 1 per cent. Within a range of 40 degrees it is 0.0249 per cent. for each degree (Fahrenheit). A shunt having 0.01 ohm at 60 degrees Fahrenheit, would be at −2 degrees Fahrenheit 0.00984 and at 100 degrees Fahrenheit 0.01009 ohms. The maximum error which can ever occur is about 2 per cent., due to a change from freezing to 120 degrees Fahrenheit, the maximum reached in any of the meters at full load. As a matter of practice, meters are so placed as to vary not over 30 or 40 degrees, on the average, either from atmospheric changes or the heating of the current.

Counter electromotive force.—Figure 15. It is plain that the change due to a rise of current in the meter here

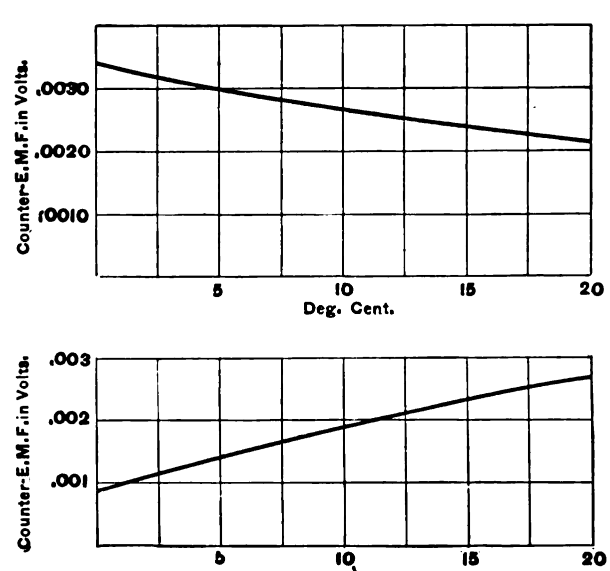


FIG. 15.

illustrated, from 0 to full load or 20 amperes, is 0.0017 volt. As this counter E. M. F. appears in practice as a factor of

resistance, its effect is shown in the current resistance curve.

It is also clear that the error due to the rise in temperature from 0 degrees to 20 degrees Centigrade is 0.0012 volt. This is one of the factors in the temperature resistance curve and is there expressed in ohms.

Bottle resistance and current.—The two errors, increase of counter E. M. F. and consequent rise in potential difference, and decrease of absolute resistance and consequent drop in

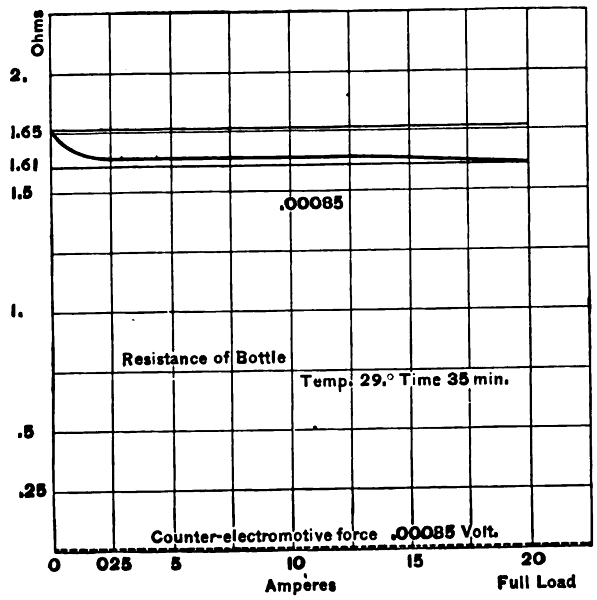


Fig. 16.

potential difference, jointly resulting from an increase of amperes, about balance each other, forming a beautiful compensation which makes this curve almost a straight line. Figure 16.

Temperature compensation.—Figure 17. Considering the bottle resistance by itself, the fall in counter E. M. F.

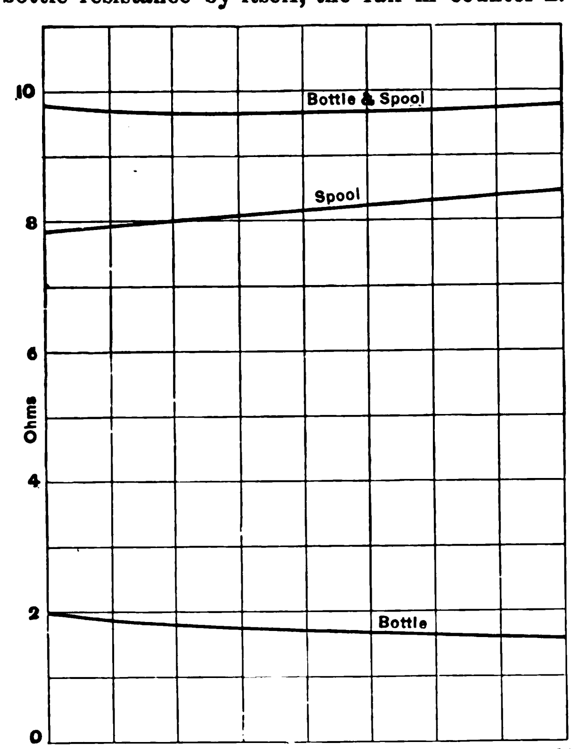


Fig. 17.

and consequent drop in potential difference with a rise in temperature, adds slightly to the drop attending the fall in resistance. These two factors are together opposed by the influence of the spool, whose copper wire increases in resistance so as to make a perfect compensation at 10° and 30° Centigrade with a slight bend in the curve at intermediate points.

Rate of deposit and current.—Figure 18. This curve, the result of the combination of the sources of error shown by the others in detail, is so close an approximation to an absolutely straight line that it is difficult to detect any material departure excepting the slight bend at the minimum load. Into the depth and sharpness of this bend the element of time enters, but after passing this point the curve runs almost absolutely straight to a maximum load.

It is especially noticeable that the curve begins at absolute zero, while with Mr. Edison's early meter of the electric motor type, and others that have followed this principle, the theoretical curve is as shown by the dotted lines. No curves deduced as are the above from long practical work have ever, so far as we can learn, been formulated of the performance of any other meter.

It is proper to say in this connection that the percentage of error from these causes is practically constant for all sizes of the Edison meter.

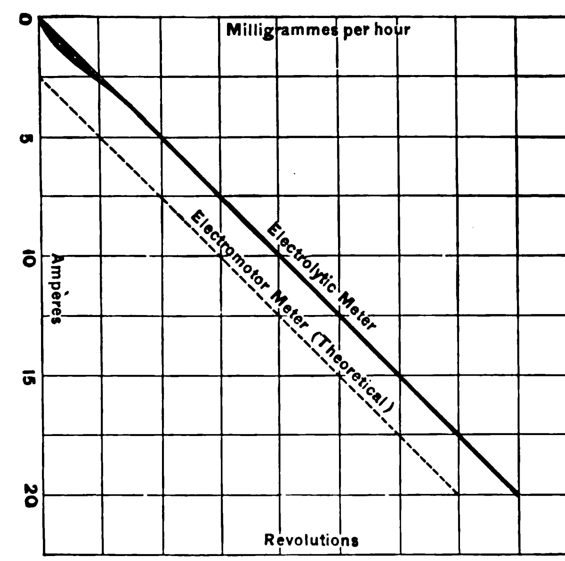


Fig. 18.

Some months ago a very careful test, covering five months, was made by the engineering department. Six Edison meters were connected in series with the meter of the Edison Electric Illuminating Company from the station by which the current is supplied to the offices occupied by the parent company. At the close of this test it was found that all of these meters registered within 1½ per cent. of each other.

An elaborate test was conducted at New Brunswick, N. J., by Mr. W. S. Howell, with seven meters put in series with ten lamps. The readings showed a variation of only one and one-half cents in the amount of the bill charged, while four of them were alike to a cent. The advantage of such accuracy is manifest not only to the illuminating company, but must also be satisfactory to the most exacting customer. One of our most experienced and successful managers testifies that in the use of about two hundred meters he found the poorest record to be very close, and sums up his experience by declaring that "without the meter they would be swamped."

But the only real criterion is that of practical success.

In order to discover what the practical men in the busines think of the meter, a circular was recently addressed to the 26 stations in the country now operating the meter system, asking for their experience and opinions. To this we have up to this time received 22 replies. That you may judge of the convictions which they express I will read the more important queries, and summarize the answers.

Question :—"Have you used meters from the starting of your station?"

Answers :—"Yes, 18 ; No, 5."

Question:—"From your experience what reasons would you quote for a change from the contract to the meter system?"

All replies to this question indicate the unanimity of the opinion that the meter is far preferable. Some of the expressions are as follows :—

(1) "There is no argument about lamp breakage. It is square dealing on both sides."

(2) "They are always superior, even to the best contract."

(3) "Less unnecessary burning ; income in more fixed ratio to expenses. Customers are able to regulate their light bills. An accurate basis instead of guess work, to estimate schedule price. Life of lamps should be much longer by use of meter, by the stopping of unnecessary burning."

(4) "We should take in a great deal more money than we do now."

(5) "There are a few exceptional cases where we are getting a little more out of contracts than we would from a meter, but as we run by night only, this difference is made possible. I refer to early closing stores. If we ran by day these would use light by day on contract, while they would rarely do so if the current were measured. I find generally that dwellings on contract are constantly fully illuminated, but the day a meter is put in they find one lamp generally suffices. I believe our income would be slightly larger if everything were on contract but our expenses would be out of all proportion. Immediately after taking charge of this station I looked up the last ten-minute record made by outgoing current, dated December 23d and 24th. It is possibly a little unfair to take a day or night so near Christmas, as more light is used at that time than at any other. The nearest aggregate I could get out of 75 tests in money value was, at one cent per hour per ten candle lamp (and the company charged at that time 1¼ cents per hour), and after deducting station and street lighting, $2,868.90, while the income of the company for that month from all sources was about $1,100. Of course during the winter months the contract consumer gets more than he pays for, and is reckless in the summer, because he thinks he gets less than he pays for."

(6) "By all means were I to build and manage a new station I would start it on a meter basis, and carry it as far as possible."

(7) "Our object was to decrease the unpaid consumption and increase the revenue."

(8) "We believe, from our experience, we can supply more on meters with the same power and get a better return from current used."

(9) "The contract gives a regular income to the company throughout the year, nevertheless in a majority of cases it is a system of robbery ; electricity should be sold like merchandise—by measurement."

(10) "The principal reason for a change to a meter system was the impossibility of making contracts which were fair to the company. Customers will burn more light than they contract for, and though under a contract system it may be easier to collect bills, at the same time the income per lamp hour will not average much more than half that of the meter system."

(11) "It prevents people from consuming an excess of current, thus unnecessarily overloading the station."

(12) "Under a contract consumers abuse the use of the light, which abuse while doing the customer no benefit, (the light not being necessarily used), increases the cost of operating and lamp breakage to the company very largely. In other words, you cannot trust customers to cut their own cloth."

(13) "More satisfactory to the consumer if he is economical."

(14) "Maximum revenue for maximum power."

(15) "Consumers can gauge the quantity of light for which they pay, to suit the business requirements."

Question :—"Do you keep meters on contract installations for your own information?" Some of the replies are as follows :—

"We have, and find a contract consumer is using about double what he pays for. Some customers have left us on this account but almost always return."

"Yes ; on all motors also.

"We run them in this way at intervals for our own satisfaction."

One of the largest of the stations keeps a meter on each contract motor.

Question:—"Have you evidence of any serious error aside from accidents? If so, please state explicitly what it is."

Eight stations, embracing the large ones at New Orleans, Rochester, La Crosse, Cincinnati and New York, reply to this question—"No."

One of the most experienced station managers makes this reply.

"We have none. In my judgment the greatest amount of complaints come from places where a notable lack of care is shown in properly preparing plates, weighing and handling ; also where leaks and grounds are most numerous. The meter has in past years located many faults for me."

Question :—"Is the feeling of your customers generally one of confidence in the accuracy of the Edison meter?"

Most of the stations reply without other remark than emphatically "Yes." Some of the answers are worthy of being quoted literally.

"In some cases our customers keep count of the hours. All such customers say the meters are correct."

"Remarkably few objections by consumers to the results obtained."

"The general feeling is one of confidence."

"The confidence is fully as great as in gas meters ; we have no difficulties on this account."

"Complaints are very few from consumers."

"The meter to our customers is a blank. While we can persuade them that the meter is correct if properly manipulated, it becomes a matter of confidence in the meter man."

"One month ago one of my customers began keeping a record of the hours his lamps were burning. When his bill was presented it was four cents in his favor ; so it is with a great many. The meter has given us good results."

"This question is rather a difficult one to answer. I have no doubt that the majority of our customers if they were asked the question would say that they did not believe in a meter. This is not due in a great many cases to any inaccuracy they have ever discovered, but merely to the general idea that meters are not worth anything, judged by the gas and water meter standards. We have had a number of customers test our meters, and in addition to this have given us strong letters of recommendation, and I have never seen the test where we had to recede from our position that the meter was correct."

"They have as much confidence in the Edison meter as in the gas meter, and probably a little more."

"Those consumers who keep a careful lamp account for a few months have faith in the meter."

Question :—"From the results of your experience with the meter system do you feel that you can endorse our recommendation to new companies that they adopt it as the most satisfactory method of serving the public?"

"Yes. I have already advised several new companies to adopt it. Contracts are bad. They soon get the best of you."

"We believe that it is the only way to sell light. We only have contracts to satisfy certain customers."

"Yes, where practicable, which however is not always the case in starting stations in small towns."

"I do not believe in the contract basis at all. I feel

that the meter is a good thing, and particularly because my economical customers never raise any questions and we never have any trouble with them."

"Yes, most decidedly for large stations. The desirability of putting in a meter system depends on the size of the plant. I do not consider that any plant of over 500 lights can afford to get along without it."

"Yes, but would offer contracts as well. Give them what they want, and if one does not prove satisfactory, give them something else."

THE EDISON ELECTRIC ILLUMINATING CO. OF NEW YORK,
16 and 18 Broad Street.

Spencer Trask, President.
John I. Beggs, Vice-President and General Manager.
J. B. Skehan, Secretary and Treasurer.

NEW YORK, December 27th, 1887.

E. H. JOHNSON, ESQ.,
President Edison Electric Light Co.,

Dear Sir—Replying to your inquiry as to the accuracy and degree of reliance placed upon the Edison meter in the commercial transactions between this company and its customers, it affords me pleasure to state that our experience has established confidence in the meter, not only on our part, but also on the part of our customers, in consideration of which I offer you the following facts:

The Pearl street station was started September 4th, 1882, and, with the exception of but two hours during the first year, has continued uninterruptedly to date.

The station is at present supplying current for 15,000 incandescent lamps and 150 h. p. of Sprague electric motors to 647 customers through a like number of meters.

Our bills are paid cheerfully with but an occasional exception, in which instances a verification of the meter is had, and the customer thereby thoroughly convinced of its accuracy.

Repeated tests of the meter, comparative and otherwise, made by ourselves, show a maximum variation of not greater than 2 per cent. and a variation from accuracy of not more than 1 per cent. These tests, combined with the practical results of five years' actual use of several hundred meters, have demonstrated conclusively to the company and its customers the efficacy of the apparatus for the purpose intended.

Yours truly,
THE EDISON ELECTRIC ILLUMINATING CO. OF NEW YORK,
By JOHN I. BEGGS,
Vice-President and General Manager.

The following, it is hardly necessary to say, was penned in the bracing air of the Rocky Mountains, and has the ring of Western enterprise:—

"I can endorse the meter for two reasons. It is the friend of the poor man as well as the company for the following reasons: It gets action on the horny-handed son of toil this way. Our contract price for lighting houses for five lights is $4.25 per month or $51.00 a year. Now there are lots of customers who cannot afford to pay that but can afford to have five lights installed and use the meter, which will probably not average over $2.50 per month or $30.00 for the year. At the same time, if they should contract for $4.25 per month, and then run till 12 o'clock for a month, they would consume $13.50 per month (if measured by the meter), but we would only get $4.25. If all did this our load would overrun our capacity, but thanks to the little box—she holds her down. It produces the same effect with business houses. Our contract price with this class is $1.50 per month (all my figures are based on 16-candle lamps). Houses having 25 lights would be $37.50 monthly; by meter we would realize $29.10 average for year, our lighting being 6 till 9. You see we get $29.10 for 3 hours light, while with contract they could burn till 12 for $37.50 or six hours light. The meter holds the load down for families when they use only one or two lights a night, but if contracted they would 'turn her loose, Murphy,' in order to play even. It is our experience that the people always manifest a desire to play even with a light company if possible, and if they can't get action one way they will another.

"Our meters here are a great deal of labor owing to the number we have in use, but still we can't get along without them and really think they are reliable if conditions are equal. My tests here have been very flattering, have had them within 1-10 of one per cent. of bill and the highest out was 2 5-8 per cent. high.

"For customers using a large amount of light it is cheaper for them to contract here, but for small customers the meter is the correct thing, and with us produces satisfaction and good results among the customers. In the summer bills are small, but the winter months balance them and run higher; when expenses increase, so do the meter bills, but with contracts it would be the same."

The reports referred to, represent the following aggregates and averages:—

Total number of lamps of all powers in 23 stations		117,501
" " " " on meters		87,856
" " " " on contracts		29,305
" " " motors		350
" horse-power of motors		1,000
" number of meters of all capacities		5,187
" " " two-wire meters		4,531
" " " three-wire meters		660
Average number of lamps per station, meters and con'cts		5,109
" " " " on meters, 23 stations		3,820
" " " " on contracts, 20 stations		1,465
" horse-power of motors		8
" number of meters per station		226
" " " lamps per meter		17
Total cost of meter operation, 16 stations	$16,235.00	
Average annual cost of operation per meter	4.03	
" " " " " " lamp	0.22	

It is also of interest to note that of the twenty-three stations equipped with meters for the measurement of seventy-five per cent. of their entire lamp capacity, and relying upon these meters for the amounts of their bills to consumers, four are earning upwards of fifteen per cent. on their capital stock; three others between ten and fifteen per cent.; three others between eight and ten per cent., and eight more between five and eight per cent. on their capital stock. Others have been operating for too short a time to yield definite results.

The following extract from a letter from Mr. J. W. Lieb, Milan, Italy, written under date of November 2d, 1888, demonstrates clearly how satisfactory the action of the meter may be made, even when the urgent cares of a rapidly growing business, forbid the one engineer of the station who is thoroughly informed on this subject, from giving the details of its operation any considerable personal attention. Mr. Lieb has labored under the additional disadvantage of being at a great distance from the birthplace of the system, and the scenes of its widest usefulness.

"We have at present actually in use in Milan some 360 meters of various types (all Edison meters), the smallest for 350 ampere-hours per month, and the largest 30,000 ampere-hours with a respective maximum capacity from four to 400 amperes.

"All the current from the mains is paid for by the ampere-hour according to the sliding scale of charges herein enclosed.

"The temperature to which the meters are exposed varies between 5 degrees centigrade and 35 degrees centigrade. We have never had occasion to apply thermostats to the meters. The results of our experiments and our general experience with the meter have given us confidence that, if carefully treated, its indications are fairly reliable, the maximum error (low reading), occurring with light loads.

"While we have some consumers whose consumption of current is comparatively uniform throughout the year, the majority (among whom many apartments) consume little or no current during the summer months, some consumers closing their apartments and making the meters inaccessible for four or five months.

"Our consumers are as a rule very close, a number keeping careful account of their lamp hours (ampere-hours), from month to month, the larger ones having clerks specially delegated for that purpose.

"This fact, coupled with the unfavorable conditions of

supply above noted, makes it necessary to apply all precautions to avoid contestations, and I am glad to say we have been fairly successful in meeting the difficulties.

"We keep a careful half-hourly register of the indications of the main station ammeters and the feeder ammeters and find them to agree with each other, and their sums with the ampere-hours given monthly by the meters within a small percentage of error which we have observed is a maximum during the summer months, the sum of the meter indications being slightly low."

Such abuses of the contract system as are shown by the foregoing expressions are so manifest to many contract stations from which we have asked for no letters, that some of them are already changing to a meter basis, and it is evidently only a matter of a short time when others will be compelled to do likewise.

At every meeting of the Association of Edison Illuminating Companies there has been a full and impartial discussion of the relative merits of the two methods. The result may be briefly and forcibly summed up in the following, unanimously passed at the meeting of the Association held at Chicago, Illinois, February 9th, 1888:—

"*Resolved*, That after a full discussion of the relative merits of the meter and contract systems in the numerous meetings of this Association, that it is the sense of the Association that the Edison meter is accurate, that the system is not too expensive for stations above 1,000 lights, and that the best financial results are invariably secured in a station selling by meter."

Recent improvements.—Nearly a year ago a series of exhaustive tests was undertaken at the laboratory of Mr. Edison, to determine whether in the light of years of experience since the initial experiments upon which the first methods were based, advantageous changes could be made.

The first result of these tests was the perfection of the general details of the three-wire meter, then being offered to the Edison stations. The present form of connecting spring clip was at once introduced. A diagonal arrangement of terminals, making it easy to connect from either side or from below, followed after. Then the production of pure chemicals by the Edison laboratory, and the elimination of the error due to oxidation (already referred to) by proper treatment of the solution.

At a meeting of the Standardizing Bureau, held December 17, 1888, it was voted to authorize the discontinuance of the two largest sizes of plates (40 and 80 amperes), and use in their places the 20 ampere plate with a proper change in the compensating spool in each case. It was found perfectly feasible to measure the shunt resistances and weigh the plates more accurately than heretofore, thereby effecting a substantial saving in cost and care of large plates. As an illustration, a 200-light plate only needs to be weighed to one-sixteenth of the exactness in units of what is necessary in a 12-light plate to secure the same percentage of accuracy.

It was also decided to authorize the use of one bottle in place of two for the three smaller capacities, which, as appears by the average figures given, constitute a large majority of the total number in use. This will probably be followed by a change in all sizes as soon as confidence in the feasibility of this plan becomes general. One-bottle meters for two-wire uses, and two-bottle meters for three-wire, will therefore be immediately produced.

These important changes, which it will be observed simply follow as a natural result of the confidence established by experience, will probably be supplemented by others, none of which will, however, modify any essential features of practice, but simply apply processes which add nothing to the expense but tend to eliminate the already small sources of error. Among those indicated as likely to be recommended are a reduction in the size and change in the form of the bottles and method of closing; a slight change in the specific gravity of the solution, and a modification of the treatment of the plates by which the active surfaces shall be limited to those placed directly opposite each other in the cell.

These minor changes will aid still farther toward the result which Mr. A. E. Kennelly (under whose personal supervision the present tests are being made) predicted in a recent lecture would be realized, namely: that "The Edison electrolytic meter will in the future be recognized as the simplest and most accurate apparatus of its kind in commercial use."

An interesting application of this Edison meter principle has been made in England, and is described as follows in the *Electrician* article already quoted, relative to a multiple-series installation at Brighton:—

"The objections to the electrolytic method are absent, when it is employed in connection with a constant current distribution. In the first place, we have now to measure the 'volt-hours' across the terminals of the house connections, so that the meter is a shunt to the whole installation. By placing a high resistance in circuit with the meter in order to reduce the current in the shunt circuit, no error is introduced. Secondly, by integrating the E. M. F. and assuming constant current, we are introducing no non-existent factor; in fact, the current at Brighton is actually maintained constant within one per cent."

This suggests interesting possibilities in measurement of energy supplied to customers of series circuit systems.

I have not taken your time this evening to prove by aggregation of testimony simply that a meter basis is the proper principle, or that the electrical fraternity needs it and should be educated to its use. This is self-evident. My aim is to show by the incontestable logic of facts that it is entirely practical and economical to accomplish all that is required by a method which is widely applied, and to emphasize by varied but singularly harmonious quotations from the experience of men who are by its help earning dividends, the result of "Six Years' Practical Experience with the Edison Chemical Meter," which is the topic of my paper.

A SKETCH OF THE HISTORY, DEVELOPMENT AND PRACTICAL APPLICATIONS OF THE ELECTRICAL CONDENSER.

BY WM. MAVER, JR.

PART I.

IT can safely be said, I think, that while there may be instruments of more importance in the applications of electricity than the condenser, there is none which has more varied and interesting uses in practical as well as experimental work than that instrument.

This was particularly brought to my attention during researches into the history of the condenser and its applications in telegraphy in connection with an important patent suit brought a few years ago by the Western Union Telegraph Company against the Baltimore and Ohio Telegraph Company, to restrain the latter company from using the condenser as a "static compensator" in duplex telegraphy.

A number of items concerning the history and applications of the condenser I noted at the time for future reference, and while I do not pretend that, as elaborated in this article, those notes will exhaust the subject, yet I venture to hope that they may be read with more or less interest by some whose duties or studies have not made them acquainted with the history and various applications of the condenser.

It will be apparent, from a comparison of the following quotations and illustrations from the works of prominent writers on electrical subjects at different periods, that the apparatus generally known to-day as the condenser is quite a different instrument, both as regards its form and function, from that to which the same name was originally applied.

Clark and Sabine's Electrical Tables and Formulæ, 1871.—"Accumulators, or as they are commonly called, condensers, are used for comparing the electrostatic capacities of cables, the electromotive force of batteries, for joint testing, and for preventing earth currents in submerged cables."

Preece and Silverwright's Telegraphy, 1876.—"A condenser or accumulator is a term applied to an apparatus composed of alternate layers of tin-foil and paraffined paper (or mica) so arranged as to form a flat Leyden jar of large surface, and constructed to give us whatever capacity we require."

Kempe's Electrical Testing, 1887.—"A condenser is merely a Leyden jar exposing a large surface within a small space."

Stewart and Gee, Electricity and Magnetism, 1887.—"A condenser for the purpose of this chapter may be considered as consisting of sheets of an insulating material, arranged alternately with sheets of a conducting material, &c."

S. P. Thompson's Electricity and Magnetism, 1881.—"Their general form (microfarad condensers) is shown in figure 1, which represents a ⅓ microfarad condenser."

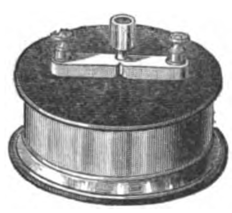


FIG. 1.

Prescott's Electricity and the Electric Telegraph, 1888.—"The condenser is an apparatus by means of which a large quantity of electricity can be gathered on a small surface.

Cavallo, in his Philosophy, 1803, thus describes a condenser and its action: "If there be a source of electricity which, when communicated to an electrometer, is too weak to affect it, let an ample insulated plate communicate with the body which furnishes the weak electricity, and the plate so situated will acquire a considerable quantity which, whilst this plate is opposed to the other, will not affect the electrometer; but if afterwards the receiving plate be removed from the vicinity of the other plate, its capacity for containing electricity will be diminished, and of course the absorbed electricity will appear much stronger upon its surface," etc. Such a receiving plate was called a *condenser* by Volta. Dr. Lardner observes concerning the condenser: "In the estimation of small quantities of electricity it is analogous to the microscope in the examination of visible objects, and it stands in the same relation to the electroscope as the compound microscope holds to the micrometer screw and vernier in astronomical instruments."

Noad's Manual of Electricity, 1855.—part i., p. 61—Referring to condensers,—"instruments contrived for the purpose of rendering evident very minute traces of electricity.

Sir Wm. Snow Harris, Frictional Electricity, 1867, p. 90—"The object of the condenser is to render sensible to the electroscope minute quantities of electricity, which, without its aid, would be inappreciable."

The original condenser as used by Volta was constructed as represented in figure 2, and is thus described in Noad's Manual of Electricity, 1855. "It consists of two circular metallic discs, the surfaces of which were covered with a thin and uniform coating of amber varnish; the lower disc B was supported on a metallic stand D, the upper disc, A, called the collector, was provided with an insulating handle, C, and a short wire terminating in a metallic ball, E. The body, the electricity of which was to be investigated, was brought into contact with E, the electricity thus communicated to A acting by induction, through the thin non-conductor on B, confined the electricity of the opposite kind repelling its similar electricity; at the same time B, being in perfect electrical communication with the earth, had a constant supply of neutral electricity conveyed to it

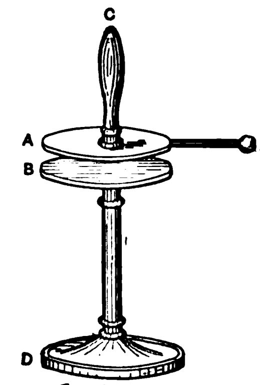


FIG. 2.

which in its turn underwent a similar decomposition. This process lasted until the *condenser* had received the full charge answering to its surface. The collector A being suddenly raised by its glass handle, taking care to keep it parallel to its base, the electricity accumulated upon it could be transferred to an electroscope for examination."

It was usual, however, to attach the condenser directly to the gold leaf electroscope, as in figure 3. In this case one of the plates of the condenser is mounted on a joint that is movable at the bottom so that it may be moved to and away from the other as shown in the figure. "By the induction of electricity on the surface of the movable disc several times and by its reaction on the electrometer (electroscope) an accumulation of the electric force is affected by which means the presence of otherwise inappreciably small quantities of electricity is detected."

The Franklin plates as described in Franklin's letters, and alluded to by Priestly as a modified Leyden jar, in the quotation below, constitute perhaps the earliest description of an instrument to which the modern condenser most nearly corresponds.

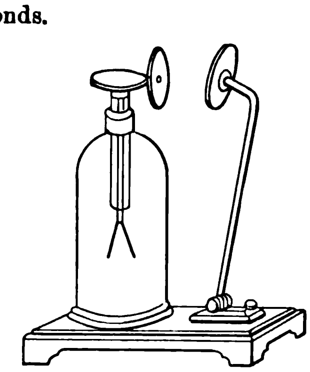


FIG. 3.

"Dr. Franklin constructed an electrical battery consisting of 11 panes of large sash glass coated on each side and so connected that charging one of them would charge them all. Then having a contrivance to bring the giving sides in contact with one wire, and all the receiving sides with another, he united the force of all the plates and discharged them all at once."

Akin to this also is the Franklin "pane," shown in figure 4, which consisted of a pane of glass coated on both sides and supplied with suitable connections for charging and discharging.

The invention of the electrical condenser as defined by Cavallo, Noad and Harris, is attributed by Noad, Bakewell, S. P. Thompson, and others, to Aepinus or to Aepinus and Wilcke. But Noad credits Volta with having brought it into the service of electrical science.

Sir Wm. Snow Harris, however, in the preface to "Frictional Electricity" takes up the defense of Volta as the inventor of that instrument, and incidentally states that "M. Biot in his life of Volta seeks continually to disparage the quality of mind of that truly great man, upon the ground that his researches and discoveries had not a rigor-

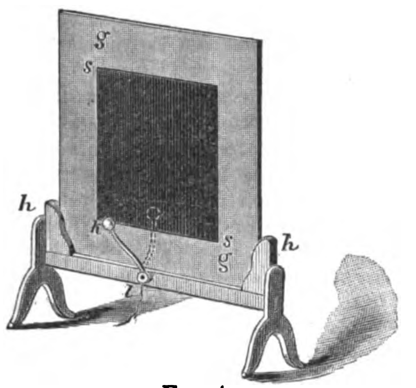


FIG. 4.

ous mathematical basis, etc., and is hence led, although constrained to admit the vast genius of Volta, to refer nearly all Volta effected to previous principles mathematically deduced by Aepinus, although no one ever heard of the condenser or the electrophorus before Volta. Still we are informed that the principles were foreseen and their theory given twenty years before by Aepinus."

The evolution of the Aepinus induction plates into the form of apparatus known to-day almost universally as the electrical condenser had begun to take shape prior to 1840, but the manner in which the instrument is referred to by different writers seems to indicate that it had not yet received a definite name and further that it was classed neither with the Leyden jar nor with the Volta condenser. Indeed it may be noticed that both prior and subsequent to 1840 various writers carefully avoid applying either the term condenser or Leyden jar to the instrument, and instead refer to it as a "reservoir," "extended, insulated, metallic surface, etc." For example, Sturgeon in his Annals of Electricity, 1836, refers to what has since been termed by others, a card-board condenser, as follows: "These boards answer exceedingly well as a *reservoir* for low intensities. They may be coated to within an inch of the edge all round and placed upon their edges either on a piece of glass or on a board properly prepared and arranged to any extent required, like the plates of a voltaic battery, but when considerable intensity is desired it is better to use thin glass."

Again referring to an arrangement, which he says is a modification of his card-board reservoir, used in connection with an electro-magnetic machine of Rainey's in the same year, Sturgeon writes, "about three yards of varnished silk cloth were coated on both sides by broad strips of tin-foil and coiled around a cylindrical nucleus of wood, an intervening ply of silk preventing the two coatings from touching."

Again, in Silliman's Journal, 1838, Professor Page, in describing a series of very striking results from the secondary current of a new magneto-electric machine, states, "It caused the gold leaves of the electroscope to diverge strongly without the aid of a Leyden jar or extended insulated metallic surface."

Still later, in Bakewell's Manual of Electricity, edition 1857, is found the following: "At the recommendation of M. Fizeau a large conducting surface consisting of several square feet of tin-foil pasted on each side of varnished silk, is connected with each of the wires through which the voltaic current is passed."

In 1854 C. F. Varley, in British patent No. 2,555, for "Improving and applying Dynamic Electricity," describes a form of condenser practically similar in construction to those in use to-day, which he termed "induction plates" and describes as follows, with a diagram here reproduced as figure 5, (which is virtually the present conventional manner of graphically representing the condenser.) "Figure 5 is an end view of a series of induction plates, which are to be laid close to each other, but here they are separated to show them. A pile of these form a Leyden battery. They may be put together in various ways * * * the sheets (induction plates) are of tin or other metallic foil (separated by) sheets of oiled silk, gutta-percha or other non-conducting surface * * * the gutta-percha (or insulating) sheet being larger in every way (than the metallic foil) prevents the opposite foils touching each other."

In his British patent 1,509, 1859, Mr. C. F. Varley still adheres to the term "induction plates" in referring to condensers.

Of course it is not meant to imply that these writers were not aware that the electrical law or laws governing the action of the Leyden jar, Franklin's plate, etc., were similar to those governing the Volta condenser, but rather to show that they were so familiar with the specific function of the condenser as then understood that the use of that term would not have properly defined, to their minds, the new arrangement and construction of the plates to which they had reference.

Some subsequent writers, however, perhaps losing sight of the earlier specific function of the condenser, have had no hesitation in defining the term; as, for instance, in Beechey's Electro Telegraphy, page 95, it is said, "* * * This is the condenser, the original type of which is known as the Leyden jar, which was a glass jar with a coating of tin-foil pasted carefully inside and out," etc.

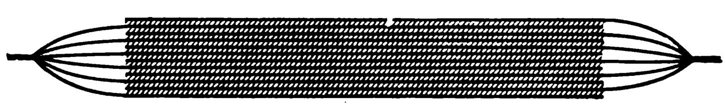


FIG 5.

In Gordon's Electricity and Magnetism, vol. 1, page 67, it is stated, "A Leyden jar is sometimes called a condenser because it was formerly supposed that the strong electrical effects observed were due to the condensation of an electrical fluid or fluids."

The term condenser as applied to the Leyden jar has been more frequently used within the past twenty years than, so far as I have been able to discover, at the time when its effects were supposed to be due to the condensation of an electrical fluid or fluids.

The changed meaning of the term "condenser" has been thus briefly traced as another instance of the gradual manner in which a name or term applied to an instrument having originally a specific function may be transferred to an instrument not necessarily having that function, and the original function be practically lost sight of. In this particular case the original object or use of the electrical condenser is already omitted from some modern text books of electricity.

There is but little doubt that the term condenser will now adhere to the instrument at present bearing that title. There was at one time a disposition to designate it *accumulator*, but that word has since been applied almost exclusively to storage batteries.

The meagre descriptions of the "induction plates" of Sturgeon and of Fizeau, already quoted, show a very crude form of condenser. These were vastly improved upon by Mr. C. F. Varley, yet we find him saying in his British

patent No. 206, 1860, "Induction plates being bulky and expensive I use in most instances plates or wires of platina. Two of these plates are placed in each cell containing sulphuric acid and water, a number of these cells are connected together like a voltaic battery, consisting of plates of the same metal, instead of dissimilar metals; when so many of these are used that the battery cannot decompose the water they become induction plates of great inductive capacity, and a few inches of surface give as great inductive capacity as many miles of submarine cable."

Again, in patent No. 3,453, 1862, Mr. Varley states, "To save expense the resistance of this test circuit may be increased say 10-fold when the induction plates are reduced in size in like proportion, etc. * * * Having found difficulty in constructing large induction plates with certainty I have been led to try, amongst many other insulators, paraffine, and I find that paper saturated with it forms an excellent insulator for this purpose."

Even in 1867, it would appear from a report of a committee of the British Association on the determination of a unit of capacity (B. A. proceedings for that year) that not much advance had been made in the construction of condensers. This report is of so much interest as detailing the state of the art as regards condensers at that time that it is given here almost in full.

"The determination of a unit of capacity has occupied the sub-committee during the past two years. Very considerable difficulties have been encountered and are not yet wholly overcome. The methods by which electro-static and electro-magnetic units can be determined are sufficiently simple in theory, but they assume that the condensers or Leyden jars compared have a definite capacity, and that with a given E. M. F. between the surfaces a definite quantity of electricity will be contained in the jar or condenser. This is very far from true with condensers of the ordinary form. Whether the dielectric separating the plates be glass, mica, gutta-percha, paraffine, ebonite, or any other known solid insulator, an absorption of electricity takes place. The longer the plates are charged the more electricity the condenser will contain, and conversely it will continue to discharge itself for a long period after the inner and outer armatures have been joined. With some of the best insulation the effect will continue for hours if not days. Condensers made with these solid dielectrics have therefore no definite measurable capacities. This capacity will differ according to the time during which they have been charged, and it may vary also with extreme variation in the electromotive forces employed, although this latter change has not been detected when the differences of potential are such as between one Daniell cell and two hundred. Only gaseous dielectrics appear free from this embarrassing peculiarity, called absorption, polarization or residual charge. One object of the sub-committee has been to construct condensers in which air alone separates the induction plates. But new difficulties arose in carrying this idea into practice. Some support for each plate was necessary, and then leakage occurred from one plate to another over the surface of any small insulating supports employed, such as glass balls or vulcanite stems. It was possible by great care in drying the air occasionally to make condensers of this type, which would remain insulated for a short time or even for some months; but long experience has shown that an artificially dried atmosphere cannot be conveniently maintained in any instrument which is not hermetically sealed. Dust also accumulated between the plates of the trial condensers; this altered their capacity and increased the leakage from plate to plate. Even a single filament of dust by springing up and down between the two electrified surfaces would occasionally bring them to the same potential with great rapidity, neutralizing the charge. Moreover, a condenser of this type could not be taken to pieces and cleaned, for no mechanical contrivance would insure that the parts after cleaning would return to their original position so exactly as to constitute a condenser of the same capacity before and after cleaning. It is therefore clear that an air condenser can only be constructed in a hermetically sealed can containing an artificially dried atmosphere; and even with those conditions, excluding the graduated and adjustable condensers which were first tried, the air condenser is not easily constructed. For large capacities which are alone useful in connection with practical telegraphy the plates require to be so numerous and large as to make the expense great and the bulk very inconvenient.

"But meanwhile practical men have introduced condensers of a more convenient form, overlooking the disadvantages which they all possess of ill-defined capacity. These condensers consist of sheets of tin-foil separated by paraffine and paper, a preparation of gutta-percha, or mica, three plans adopted by Mr. Varley, Mr. Willoughby Smith and Mr. Clark, respectively.

"Mr. Jenkin has adjusted a mica condenser approximately equal to 10^{-14} absolute electro-magnetic units. The capacity of this condenser is assumed as that which it possesses after electrification for one minute, and is measured by the discharge through a galvanometer in manner usually practiced when testing the charge of a submarine cable. * * * While, therefore, the new provisional unit of capacity has no claims to a high scientific accuracy, it will supply a practical want, and introduce a unit based on the principles adopted by the committee, in place of the random measures supplied by a knot of Persian Gulf or Atlantic cable."

This knot of cable as a unit of capacity, although perhaps somewhat crude, was a decided advance in what may be called the unit of capacity of a Leyden jar in the early days of the history of that instrument, which was determined by the length of wire which its discharge was able to fuse. It appears (Nicholson's *Journal of Natural Philosophy*) that the highest charge of a battery belonging to Dr. Van Marum, and containing 135 square feet of coated surface, could just fuse 180 inches of iron wire $\frac{1}{150}$ of an inch in diameter, or six inches of iron wire $\frac{1}{40}$ of an inch in diameter. Another battery belonging to the same person, and containing 225 square feet of coated surface, could melt, with its highest charge, 300 inches of the first mentioned wire, or 10 inches of the last. Also, the highest charge of a third battery, which contained 550 square feet of coated surface, could fuse 25 inches of the latter wire." Cavallo, on this point, says: "The force which is required to melt wires of the same metal must be greater or less, according to the length and thickness of the wire; but it is far from bearing any direct proportion to the quantity of metal. For if a wire of a certain length and diameter be barely melted by a large battery (Leyden jars), a wire of equal length and twice the substance cannot perhaps be melted by less than ten such batteries," which is interesting as showing that Professor Cavallo was here in a fair way to discover the actual heating action of the current, which, as is now so well known, varies as $C^2 R$.

Within the last few years there has been a decided improvement in the construction of condensers both as regards stability of the insulation and the retention of charge, two qualities that go together. Standard condensers of one-third microfarad capacity, made in Europe, have shown an insulation resistance of over 20,000 megohms, and much higher insulation can doubtless be furnished. Standard condensers of similar capacity made in this country have shown a resistance of over 28,000 megohms, and a still higher insulation can be obtained if desired. But for ordinary testing and experimental purposes this insulation is found sufficient.

Tests made of paraffine paper condensers designed for practical application in telegraphy and particular electric lighting purposes, have demonstrated the capability of such condensers to withstand being placed between the poles of a 1,000 volt alternating current dynamo for twenty-four hours without injury, and hundreds of similar instruments are in use in this country, in telegraphy and telephony,

under conditions which virtually subject them to the strain of lightning arresters, also without injury. These condensers are of American manufacture, and in view of the fact that at least one system of telegraphy in Europe has been in some instances abandoned, partly, at least, on account of difficulties thrown in by the failure, from lightning, of the condensers employed in its operation, while another system in this country has been more or less seriously injured by the use of an inferior quality of condensers, and as others may be deterred from developing apparatus or systems requiring the employment of this useful instrument on the assumption that reliable condensers cannot be manufactured at commercial rates, no apology, need, I think, be offered for introducing the foregoing information as to the high merit of American condensers.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.[1]

BY A. RECKENZAUN.

(Concluded from page 480, volume vii.)

WITH this issue we bring the series of "Notes" to a conclusion. The subject has by no means been exhausted —indeed, it has received but a general treatment; and the original object—viz., that of publishing a few important experiments and observations—had to be kept in view. Great strides have been made in the manufacture of storage batteries since the commencement of these "Notes," but the principles enunciated therein from time to time still hold good within the limits of their treatment. By far the greatest portion of these articles related to results of experiments made by the author, and these were limited to storage batteries of the most popular kind, composed of lead and oxides of lead. Up to a recent date these were the only commercially successful ones. Mr. Howell's new storage battery, which is now being introduced by Messrs. Crompton & Co., appears full of promise, but little is as yet known concerning its general properties. Mr. Howell's plates consist of spongy lead slabs produced by a peculiar process, the essential feature of which is kept secret. Contrary to popular notions, these plates are made to give considerable storage capacity, when compared with their weight, and the process of "forming" is said to occupy not more than two or three weeks, and without frequent reversals, differing therefore from the ordinary metallic lead or Planté types. Mr. Howell informed the author that a sample cell, containing 17 plates, weighing together 35 pounds, and each plate measuring 6 by 6 inches, gave a capacity of 185 ampere hours, at an average rate of 30 amperes, and that for the space of 10 minutes a discharge rate of 600 amperes had been maintained. According to this statement we have the very interesting fact that spongy lead plates can be made to yield 5.28 ampere hours per pound of metal at a considerable rate of discharge. Although no mention is made as to the durability and cost of these plates, we are assured that these items will be found satisfactory.

Copper as an element in secondary batteries.—About seven years ago Mr. Sutton invented a storage battery composed of a lead plate to be peroxidized, and a copper plate to be alternately dissolved and deposited from the solution of sulphate of copper. This battery has not found any industrial application for obvious reasons: the action in a cell with metallic solutions is not constant, the layer of liquid in contact with the metal changes, and eventually refuses to act. In charging, soon after the first action there is no metallic salt present to decompose, but merely acid, which gives off gas, and then the metal deposit becomes non-adherent. In discharging, the metal salt forms too rapidly to dissolve and crystallizes on the plate. These crystals form "trees," and eventually short-circuit the plates. It is for this reason, also, that the zinc-lead accumulator remains still within the precincts of the laboratory.

Messrs. Commelin, Desmazures and Bailhache in May, 1887, brought out a new accumulator, in which copper plays an important part. For the description of this we are indebted to M. Reynier's work, "L'accumulateur voltaïque."

The positive electrodes of this battery are made of porous plates, obtained from finely-divided copper under a pressure of 600 kilogrammes per square centimeter. Electrolytically reduced copper, free from oxides, is used.

The negative electrodes are of tinned iron plates; these are amalgamated. The tin has to hold the mercury which does not adhere to the bare iron. The receptacle is made of tinned sheet steel; the negative electrode rests at the bottom of the box, and it is in contact with it. The electrolyte consists of water, zinc and potash in the following proportions:—

Water	1,000
Zinc	144.67
Potash in solution	209.82
" free	313.72

The positive electrodes are enveloped in parchment paper, and insulated from the negatives by means of glass rods. The parchment is stitched on, and although the seam is not watertight at first, it becomes so through the action of the liquid, which causes the paper to stick fast. The parchment undergoes a change through the action of the alkali; it swells and becomes brittle, but it appears to hold on a considerable time without breaking, if no mechanical disturbance takes place.

Without the parchment the action is irregular; the oxydation of the positive electrode is not complete, and deposits of zinc are mixed with copper; hence want of adherence and local actions or short-circuits through the formation of "trees," as in other batteries where metallic deposition takes place. These envelopes, therefore, play a very important part.

M. Finot, the chemist who examined this invention, gives the reactions during the discharge thus:—

$$\mathrm{Zn + KO, HO, Aq + Cu_2\,O = Zn\,O, KO, Aq + 2\,Cu + HO},$$

but there appears to be a doubt as to whether this is the correct rendering of the equation, and it requires confirmation; curiously, there are hardly two authorities who agree on the subject of chemical reactions in secondary batteries.

M. Finot ventures another theory in the *Bulletin de la Societé Internationale d' Electriciens*, where he states that during the charging of a copper accumulator one observes a curious phenomenon, which tends to show that oxygen does not combine with the copper, but that it may be occluded, and this occlusion may be due to peculiar properties of the porous plates.

When the apparatus is being charged one may observe that from the commencement of charging the level of the liquid rises and continues to rise until the charge is discontinued. On the other hand, during the discharge the reverse takes place; the liquid falls gradually, and does not resume its original level until the battery is entirely discharged. If, says M. Finot, the oxygen did combine with the copper, no rise in the level of the liquid would manifest itself until all the copper had entered into combination. Thus the oxygen fills the pores of the plates, displaces the liquid, and causes the increase in volume.

During the discharge again, oxygen should disappear immediately, and the liquid resume its normal level a few minutes after closing the circuit, but this is not actually the case.

M. Reynier thinks that these observations do not appear sufficient to demonstrate that occlusion of oxygen takes place in the positive plates, and he asks whether the rise of

1. From the *Telegraphic Journal and Electrical Review* (London).

level in the liquid is not due to changes of volume in the plates, one of which is oxydized and the other covered with zinc? In order to decide this question the densities of the liquid as well as of the positive plates should be ascertained after the charge; from this may be deduced the total volume of the electrodes and of the liquid. By this method it could easily be determined whether the hypothesis regarding the occlusion of oxygen is correct.

The following weights and dimensions were given by M. Commelin, and they refer to an accumulator which has been constructed for the purpose of propelling a small torpedo boat. The storage capacity of the cell has been ascertained in the laboratory by the inventors :—

Weight of cell in working order	22.046 lbs.
" " 5 positive plates	4.25 "
" " 6 negative "	2.32 "
Height " positive plate	11.02 inches.
Width " " "	4.92 "
Height " negative "	11.81 "
Width " " "	4.92 "
Surface of positive "	54.22 square inches.
" " negative "	58.1 " "
Receptacle, length	5.905 inches.
" width	8.346 "
" height	15.75 "
" weight	2.204 lbs.
Electrolyte (1.55 S. G.) weight	13.224 "
Useful E. M. F.	.75 volt.
Current, charging	15 amperes.
" discharging	48 "
Time of charging	30 hours.
" " discharging	9½ "
Useful capacity	413 ampere hours.
" "	.42 h. p. hour.
Capacity per pound of cell	18.72 ampere hours.
" " "	14.12 watt hours.
Weight per h. p. hour	52.47 lbs.

According to a note (communicated in March, 1888) by M. Krebs to the Académie des Sciences on "L'Essai d'un moteur électrique alimenté par des accumulateur destinés à un bateau sous-marin," the total weight of a Commelin-Desmazures battery to give 1 h. p. hour was found to be 37 kilogrammes, or 81.55 pounds.

This is not a very great advance upon what has been accomplished with certain lead storage batteries, weight for weight. The volume, or dimensions of the copper storage battery are smaller than those made of lead, whilst the efficiency may be alike in both.

With regard to cost one may infer that lead and dilute sulphuric acid must be cheaper than copper and potash; and as to other points of interest we have to ask whether it is necessary to amalgamate the negative plates frequently? How long will the parchment envelope last? What changes take place with the electrolyte in the course of time? No doubt positive plates made of copper are more durable than those made of lead, but the general item, *depreciation*, has yet to be ascertained; if it turns out to be a very small quantity then we may ignore the question of first cost, and then we can congratulate Messrs. Commelin, Desmazures and Bailhache, as well as those in search of a novel storage battery, for an achievement, the beneficial results of which cannot easily be over-estimated.

ABSTRACTS AND EXTRACTS.

ELECTRIC LIGHT FOR MILITARY PURPOSES.

THE following account of experimental firing at night by electric light in Germany is quoted by the *Electrical Review*, of London, from the *Elektrotechnisches Echo*.

WE have just had occasion to witness some nocturnal experiments in rifle shooting by the aid of the electric light in a large garrison, and we may say that all the participators in the trials were exceedingly well satisfied with the result. Last year some similar trials were made by the artillery at Jüterbogk, when the bursting of shells could be distinctly seen at a distance of 2,700 meters. On the present occasion the light was found also to serve well for rifle shooting. The night was dark, a few stars only being visible. At a distance of 400 meters figures and circular discs were fixed as targets. The electrical apparatus was posted 200 meters behind the firing party, and consisted of a wagon carrying a steam engine, a dynamo-electrical machine, and a reflector. The engine was of 18 h. p., and the lamp an arc lamp. The light was perfectly steady without the least flickering. When working with 7 h. p. the machine threw a beam of light to a distance of 4,000 meters, and at that distance pencil writing could be read.

When the trials began we placed ourselves next to the machine, whence we were able to see distinctly the targets, so that it would have been impossible for anyone to have approached within the focus of the light or got near the machine unseen. This would have been the more impossible, as the micrometer action of the reflector enabled the operator to sweep the horizon.

The shooting trials were carried out in the following manner :—The soldiers lay partly in the focus of the light itself so that the sights were sharply illuminated, and these men hit the circular targets at man's height nine times out of ten. Another squad of men lay in darkness firing at the illuminated targets, and their firing was hardly inferior to that of the former.

However, preference must beyond doubt be given to the former method in war, as it is utterly impossible for the enemy to see their opponents when lying in the dazzling light. But if the men lie in darkness the enemy will easily discover them through the flash of their guns.

As regards the electrical apparatus it can only be rendered unserviceable by a bullet hitting the bar to which both carbon points are fixed, as even if a bullet break the glass in the reflector the light will not be affected in the least. The only moment of danger to the apparatus, is when the carbon points are being changed, when, if the force be too great, the apparatus may cease to act. If so, the otherwise intensely white light assumes a violet hue, and in a few seconds the reflector ceases to act, and the disc looks like the moon rising when full, shining with a dull red lustre. At that moment the enemy may destroy the apparatus with the greatest ease by throwing shells at it. It must, therefore, be the chief task of the electrical engineers to take care that the apparatus is kept working steadily and evenly.

THE DURATION OF LIGHTING FLASHES.

IT is well known that the lighting flash, or the spark between the terminals of an influence machine, exists for so short an interval of time as to be beyond measurement by any ordinary means. But notwithstanding the acceptance of this knowledge, the peculiarities of some of the flashes photographed have been supposed to be due to the camera,

or the sensitive plate, being at the time in a state of vibration. To test this line of thought, Mr. James Wimshurst has made a dark slide for his camera, in which is fitted a train of clockwork carrying a disc, upon which is an arrangement for holding the sensitive plate. When all is complete for photographing a flash, the clockwork is wound up, the sensitive plate then rapidly acquires great velocity, which at the maximum reaches 2,500 revolutions per minute, and with the plate rotating at this speed the spark is photographed. The annexed engraving is from a photograph taken under these circumstances; as will be seen, it in no way indicates movement in the sensitive plate, for

the photograph throughout its length is as sharp and as clear as though the plate had been at rest. The experiment is interesting, for it not only shows the infinitely short existence of the spark, but it also shows that chemical change in the sensitive film takes place in an equally minute interval of time.—*Engineering.*

ELECTRO-PHYSIOLOGY.

On the 6th of November, at Owens College, Manchester, Professor Stirling delivered a lecture on the electrical properties of the tissues, but especially of those composing the nervous system. There are about fifty species of fishes which are known to have specially modified organs for the generation and discharge of electricity. These organs when at rest do not discharge their electricity; but if the animal be irritated electrical shocks are discharged, which in some fishes are very powerful indeed. By means of electrical discharges these animals not only stun their prey, but they ward off the attacks of their enemies. The animal may discharge its batteries voluntarily, but after having done so for a considerable number of times the electrical organs become fatigued, just as muscles after severe exercise are fatigued. At first sight it might seem remarkable that certain animals are provided with structures which evolve powerful discharges of electricity. This however, is not by any means the most remarkable fact. When we know that the whole of the body of the animal is traversed by the electrical current at the moment it is discharged, it does seem far more wonderful that the tissues of the animal itself are not thereby affected; not even a muscle is caused to contract, although the discharge must necessarily traverse the nervous system as well as the muscles. The animals, therefore, have an immunity from the effects of their own shocks. Darwin admitted that the presence of these organs in a limited number of fishes was a fact not easily explained on the evolution hypothesis. Recent researches, however, have shown that the electrical organs are really modified muscular organs, or the terminations of nervous structures in muscles. This fact greatly simplifies the problem. Muscles and nerve, however, evolve electricity in the living condition; and a variation of the electrical conditions of a muscle, a nerve, or even of protoplasm generally is one of the best signs of the vital activity of these structures. With Galvani's experiments on the twitchings of the limbs of frogs, there commenced the investigation of electrical phenomena, which have led to such splendid results, not only in physiology, but to the development of new means of producing electricity and its numerous applications in the arts. The lecturer demonstrated the classical experiments of Galvani, Volta, Noboli, Du Bois Raymond, and others, showing historically on what lines our present knowledge of animal electricity had been reached.—*The Electrician* (London).

A TEN-THOUSAND VOLT TRANSFORMER.

The usual tests of insulation consisting only of a measurement of the insulation resistance afford very little guarantee, especially in the case of electric light cables, for the working strength of the insulation, seeing that the test is usually made by means of laboratory batteries having a comparatively low E. M. F.

At the "Menier" electric cable works in Paris-Grenelle an alternating current transformer, made by Messrs. Ganz & Co., of Budapest, has been used since March, 1888, for the purpose of testing cable insulation as well as any dielectric. This transformer is constructed with a primary coil for 100 volts and 70 amperes, and a secondary for 10,000 volts and 0.07 amperes, the ratio of transformation being 1 : 100.

The secondary coil is divided into 10 divisions, the ends of which are led to metal contact pieces with conical holes. By means of two plugs and two flexible leads, the di-electric to be tested can be subjected to a difference of potential of from 1,000 up to 10,000 volts, and its behavior observed.

In the primary circuit there is, as well as the generator, a double pole switch, in order to cut off the primary circuit entirely before altering the secondary difference of potential by shifting plugs. A Cardew voltmeter indicates for the control of the primary potential.

Concerning the construction of the transformer, it may be mentioned that the primary and secondary coils, as well as the divisions of the secondary, are carefully insulated from one another with ebonite. The metal pieces forming the terminalsof the secondary divisions are mounted on high ebonite supports, the metal plugs being also furnished with long handles of the same material.

The transformer, together with the terminals, are mounted on a strong base board, on which there is also a double pole switch with porcelain base and handle.

This method of testing the insulation of cables affords a far better guarantee for their safe working in actual use than that of testing by measuring the insulation resistance with a comparatively low E. M. F.—*Electrical Review* (London).

THE GEYER-BRISTOL METER.

The Geyer-Bristol meter, which is described on a later page, presents several features of interest. Every one will be struck with the ingenuity and simplicity of the idea, and we are inclined to think that it will prove of some considerable practical value, though it is to be expected that the indications will be somewhat sluggish. As an ammeter, at any rate, its advantages are obvious. It is also satisfactory to know that, according to the recent investigations of C. Cranz, the differences in the heating power of continuous and alternating currents (of the same mean value) are too small to affect the reading of industrial instruments, although, as a matter of fact, the alternating current has a slightly greater effect. This is a result which we venture to think might have been foreseen, since the heat generated when the current wave is at a maximum must take time to reach the surface of the wire, and we imagine, therefore, that the higher the thermal conductivity of the metal the more nearly identical will be the effects.—*The Electrician* (London).

INAUGURATION OF THE STATUE OF AMPERE.

ADDRESS BY M. CORNU.

We find in the history of science names whose lustre increases year by year as succeeding generations appreciate more fully the grandeur and the fecundity of the work with which such names are identified. Such is the name of André Marie Ampere.

Born at Lyons, on January 22d, 1775, your illustrious fellow citizen early displayed a wonderful intelligence joined to a prodigious memory; he learned everything spontaneously.

His father whose doom it had been to perish as a victim of the blood-thirsty passions of the day, had discovered his thirst for knowledge and sought to satisfy it. "As for my son (he wrote the evening before his death) there is nothing which I do not expect from him."

The future justified this paternal forecast. Young Ampere first turned his attention to transcendental mathematics. His first work "Considerations on the mathematical theory of gaming," which contains the solution of a difficult problem in the theory of probabilities, bears the mark of a vigorous and profound spirit. He wrote it in the midst of the most trying pre-occupations at Bourg, at the Central School of the Department of L'Ain, where he was professor of physics and chemistry in 1802 and 1803.

This first work attracted the attention of Delambre, who along with Villar was commissioned to recruit the teaching staff of the lyceums then in course of creation. A second work, "The application of the calculus of variations to mechanics," earned for him the patronage of Delambre, and enabled him to leave the unpleasant position which he occupied at Bourg. He was nominated professor of mathematics at the Lyceum of Lyons.

He was thus enabled to return to his young son, Jean Jacques Ampere, who became subsequently an eminent academician, and to his wife, who was in declining health.

On her death, residence at Lyons became insupportable to him. Fortunately his patrons, Lalande, Delambre, and Laplace, called him to Paris as "repitituer" of analysis at the "Ecole Polytechnique." There, sharing his time between the philosophers and the mathematicians, he was again able to enjoy his studies, and soon won the esteem of the learned world by the profundity of his views and the variety of his conceptions.

In 1808, he was nominated inspector-general of the University, and in 1809, professor of the courses of analysis and of mechanics at the Ecole Polytechnique. Finally, in 1814, he was elected a member of the Academy of Sciences in the mathematical section.

Further memoirs touching problems in the loftiest fields of mathematics raised him to the highest rank in that science. But these researches were merely the prelude to more important discoveries. From being a great mathematician he became a still greater physicist, and it is in this character that he will be most honored by posterity.

In the beginning of September, 1820, the Academy of Sciences heard of the discovery of Oersted, that the wire connecting the poles of a galvanic battery acted upon the magnetic needle.

A few days later Ampere completed this great discovery by giving precision to all the conditions of the experiment. He was the first who defined the electric current, giving it a direction, and summing up the phenomena in the celebrated rule that "the south pole is deflected to the left hand of the current."

He detected in the movements of Oersted's needle the solution of a great problem, which had for more than a century hovered before the physicists of all countries. These movements of the needle are signals which may represent letters, and the connecting wire, if prolonged, must transmit them immediately to any distance. Electric telegraphy, in principle, was thus invented.

Ampere afterwards applied all the power of his mind to the study of electro-magnetism. At every meeting of the academy he brought forward new discoveries. Step by step he announced the reciprocity of the action of magnets upon currents, the direction of a movable current by terrestrial magnetism, the reciprocal action of currents, creating thus a new branch of science, *electro-dynamics*, and finally identifying currents and magnets.

Thus, in a few weeks, there was effected a true revolution in physics. Magnetism, which had formerly been separated from electricity, ceased to be a distinct agent. The magnetic properties, regarded as peculiar attributes of iron and steel, became a general phenomenon, common to conductors of all kinds. Ampere discovered at the same time the proper form to be given to conductors in order to reproduce most exactly the properties of magnets;—this is the electro-dynamic cylinder, or solenoid, which is made by folding a metallic wire into a helix and traversing it by a current. The helix presents at its two extremities opposite poles. If suspended freely, it shows the north like a compass, and so long as it is traversed by the current, nothing distinguishes it from a real magnet.

There only remained one step to arrive at a discovery, which involves the most extraordinary consequences in science and industry. This step was taken by Ampere and Arago in the memorable experiment in which the two illustrious friends conceived the idea of introducing a bar of soft iron into the electro-dynamic coil. The electro-magnet was invented.

When Arago, wishing to express his admiration for the work of his friend, exclaimed before the Academy of Sciences: "We say the laws of Kepler, and we shall say the laws of Ampere," he foresaw the judgment of posterity.

But the supreme testimony of admiration comes to him from abroad, from the country of Davy and Faraday. Maxwell, an illustrious English savant, ventured to say: "Ampere is the Newton of electricity."

The name of our great physicist finally acquired its great renown on the day when, by a delicate homage to the memory of the great men who have contributed most to the progress of electrical science, Volta, Ohm, Ampere, Faraday, Coulomb, the electricians of all countries, assembled in congress, determined that these names should serve to designate the various electrical units. Since that day, over the entire world, the name of Ampere, a synonym for the unit of current, is pronounced by thousands of lips in the laboratories of savants, as well as in the most modest workshops.—*La Lumière Électrique.*

REMINISCENCES OF AMPERE.

THE city of Lyons is about to erect a statue in honor of the *savant* who discovered electro-magnetism. Professor Cornu, of the Academy of Sciences, will show at the inauguration how greatly dynamic electricity is indebted to him. We will here merely give, from *Le Figaro*, a few facts concerning his private life.

André Marie Ampere was born at Lyons, in the parish of Saint Nizier, on January 22d, 1775. His father was Jean Jacques Ampere, and his mother Jeanne Antoinette Sarcey de Sutières. Fifty-two years after his death Lyons has resolved upon raising a statue to its most illustrious son, who in his life time was less honored than he deserved.

The inauguration of the monument will take place in presence of the president of the Republic. M. Carnot, an old student of the Ecole Polytechnique, will thus render homage to the most eminent of its professors.

The childhood of Ampere was passed at Polymieux les Mont d'Or, near Lyons. Here, even before he knew figures, he made long calculations by means of pebbles and beans. He early displayed a wonderful memory and a prodigious power of assimilation. He devoted himself with equal and simultaneous ardor to botany and the study of Latin poetry. As he was also by nature a mathematician, we find him combining three distinct mental types. One of his earliest researches was the application of mathematics to games of chance. He proved rigorously that the professional gamester runs to certain ruin. This investigation of Ampere's, however, has probably not cured a single person suffering from the gambling mania.

His finest and most fruitful discoveries were made in physics. In 1802, the First Consul Napoleon, offered a prize of 60,000 francs to anyone who should effect a similar advance in electricity or galvanism to that due to Franklin or to Volta.

Ampere was then engaged in researches which immortalized his name by leading him to the electro-dynamic theory. In a memoir communicated to the Academy of Sciences, in 1812, he already indicated the principle of electric telegraphy. In 1819, Oersted, of Copenhagen, discovered the action of an electric current upon a magnetic needle. This result became in the starting point of one of the most beautiful inventions of the age. In eight days he conceived and realized the entire theory of electro-dynamics, and submitted his results to the Academy on September 18th, 1820.

The duties of an inspector-general of the University compelled Ampere to traverse France in all directions, and he had the curious habit of naming his theories from the places where they dawned upon his mind.

Great, however, as were Ampere's services to science, they would, doubtless, have been far greater if he could have kept himself from metaphysics. We know that in middle life Liebig bitterly regretted the time which he had devoted to such studies in his youth. Ampere, on the contrary, became more metaphysical as he grew older. He declined to answer a letter on physical and chemical topics which he had received from Davy, having, as he said, "no longer the courage to fix his ideas upon such troublesome things." He actually kept up a correspondence with Maine de Biron from 1805 to 1815, and he regretted that many of his friends did not care for metaphysics.

He was a believer in so-called animal magnetism, and admitted that in certain conditions of nervous excitement a man might see without eyes, and read a letter with his elbow. His mind was

active only when standing. If seated at a table, pen in hand, his ideas vanished.

Ampere was exceedingly short-sighted, and, in addition, absent minded.

Of the consequences of this defect some amusing instances are on record. On his appointment to a professorship at the Ecole Polytechnique he made his first appearance in the lecture room in an old, ill-made coat, which became a standing joke among succesive series of students.

Some of these young men pretended to be short-sighted, and by degrees persuaded the kind hearted professor to write figures of such a size that the largest black-board would scarcely suffice.

One day, when absorbed in the development of a difficult theory, he mistook a duster, covered with chalk, for his handkerchief, and wiped his face with it accordingly.

Ampere was an intimate friend of Chevreul. They dined together weekly in the Rue de Babylone, with an American geologist, in company of La Reveillére-Lepeaux and Volney. Here was formulated the law of the simultaneous contrast of colors. In M. Chevreul's garden Ampere strayed at will, pursuing an idea, solving a connundrum, or catching butterflies.

Ampere was married in 1779, but had the misfortune to lose his wife as early as 1805, a calamity from which he never recovered. He passed entire days on the banks of the stream where he had first met her, and spent the time in making little mounds of sand. His death took place on June 10th, 1836, at the College of Marseilles.

The statue about to be inaugurated is said to recall very vaguely the features of Ampere. When questioned on this subject, the sculptor declared that this deviation from truth was intentional. The object was to ornament a beautiful square, and he therefore represented a handsome young man, an Apollo, which Ampere never was.—*Telegraphic Journal and Electrical Review* (London).

ON THE MAGNETIZATION OF IRON AND OTHER MAGNETIC METALS IN VERY STRONG FIELDS.[1]

BY J. A. EWING, B. Sc., F. R. S., Professor of Engineering in University College, Dundee, and WILLIAM LOW.

EARLY in 1887, the authors communicated to the Royal Society the results of experiments made by subjecting iron to strong magnetic force by placing the sample, in the form of a bobbin with a short narrow neck and conical ends, between the pole-pieces of an electro-magnet.[2] The experiments have been continued and extended by using much stronger magnetic forces and by testing samples of nickel, cobalt, and various steels, as well as wrought iron and cast iron. The large magnet of the Edinburgh University Laboratory, kindly lent by Professor Tait, was used throughout the experiments, and allowed the authors to effect a high concentration of the magnetic force by using bobbins, the necks of which had a cross-sectional area of (in some cases) only $\frac{1}{1800}$ of the cross-sectional area of the magnet cores By this means the induction $\mathfrak{B}$, was raised to the following extreme values:—

In wrought iron	45,350	C. G. S.
" cast iron	31,760	"
" Bessemer steel	39,880	"
" Vickers' tool steel	35,820	"
" Hadfield's manganese steel	14,790	"
" nickel	21,070	"
" cobalt	30,210	"

The induction was measured by means of a coil consisting of a single layer of very fine wire wound upon the central neck of the bobbin. Outside of this coil, at a definite distance from it, a second coil was wound, and the magnetic force was determined in the annular space between the two. In a paper communicated to the Manchester meeting of the British Association, the authors showed that if the force so measured could be proved to have the same value as the magnetic force within the metal neck itself, it would follow that the intensity of magnetism, $\mathfrak{I}$, had begun to diminish under the action of excessively strong fields, in the manner which Maxwell's extension of the Weber-Ampere theory of molecular magnets anticipates. In the present paper the authors discuss at some length the question of how far the magnetic force within the metal is fairly measurable by the magnetic force in the ring of surrounding air, and they show that with the form of cones originally used the force within the metal must have been less than the force outside, by an amount probably sufficient to explain the apparent decrease of $\mathfrak{I}$. The form of cone suited to give a uniform field of force with sensibly the same value in the metal neck and round it is investigated; and experiments are described in which the condition necessary for a uniform field was satisfied. The results of these experiments are conclusive in showing that no considerable change takes place in the value of $\mathfrak{I}$ (in wrought iron) when the magnetic force is varied from about 2,000 to 20,000 C. G. S. units. Throughout this range of force, the intensity of magnetism has a sensibly constant value of about 1,700 C. G. S. units, which is to be accepted as the saturation value for wrought iron. The term saturation may be properly applied in speaking of the intensity of magnetism, but there appears to be no limit to the degree to which the magnetic induction may be raised.

To produce the greatest concentration of force upon the central neck the converging pole faces should have the form of cones, with a common vertex in the middle of the neck, and with a semi-vertical angle of 54° 44′. This form, however, does not give a uniform field in the neighborhood of the vertex. To secure that the condition is that d^2F/dx^2, d^2F/dy^2, and d^2F/dz^2 shall vanish, F being the magnetic force at the vertex, which is due mainly to the free magnetism distributed over the pole faces. The condition for a uniform field is satisfiod when the cones have a semi-vertical angle of 39° 14′. When this form is given to the cones, the magnetic force in the air immediately surrounding the central neck may be taken as sensibly equal to the force within the neck, and it therefore becomes practicable to measure the relation of the induction to the force producing it—that is to say, the magnetic permeability.

The greatest attainable concentration may be calculated by assuming the pole faces to be saturated, when the cones are such as to have maximum concentrative power (semi-vertical angle = 54° 44′). Under these circumstances the magnetic force at the vertex due to the free magnetism on the conical faces is—

$$18{,}930 \log_{10} \frac{b}{a},$$

where b is the diameter of the poles at the base of the cones, and a the diameter of the central neck.

The following are probable values of the intensity of magnetism when saturation is reached in the particular metals examined:—

	Saturation value of $\mathfrak{I}$.
Wrought iron	1,700
Cast iron	1,240
Nickel (with 0.75 per cent. of iron)	515
Nickel (with 0.56 per cent. of iron)	400
Cobalt (with 1.66 per cent. of iron)	1,300

Experiments were also made with specimens of Vickers' tool steel and other crucible steels, Whitworth's fluid compressed steel, Bessemer steel, Siemens' steel, and Hadfield's manganese steel. This last material, which is noted for its extraordinary impermeability to magnetic induction, was found to have a constant permeability of about 1.4 throughout the range of forces applied to it—namely, from 2,000 to nearly 10,000 C. G. S.

The results are exhibited graphically by curves drawn in Rowland's manner, to show the relation of the permeability to the magnetic induction. In the highest field examined the permeability of wrought iron had fallen to about two.

1. Abstract of Paper read before the Royal Society, November 22d, 1888.
2. See *Electrician* and ELECTRICAL ENGINEER, vol. vi., p. 408.

POINTERS.

.... WE now know the steam engine is really a heat engine. —*Sir Frederick Bramwell.*

.... LET us accept as an undoubted fact that a general distribution of power would enable the wants of civilized life to be better satisfied, and therefore would greatly benefit industry.—*Professor Ayrton.*

.... FOND Father:—"My son, which would you rather be, Shakespeare or Edison?"
Bright Boy (promptly) "Edison."
Father :—" Why?"
Son :—"'Cause *he* is'nt dead."—*Daily Paper.*

.... HE who wishes to keep abreast with the march of science to-day must leave the college and go to the workshop and into the dark corners of private laboratories, for investigators rarely have time to write, so that text-books are years behind the science itself.—*Professor Gray.*

.... IN America the electric light wires overhead are classed as dead or alive according to the result that happens on touching them. If you handle a wire and are alive after it, the wire is dead; if *you* are dead, the wire is alive. The wires are arranged within easy reach of an ordinary umbrella for testing purposes. and as a rule they are very much alive.—*Electric Plant* (London).

.... INSTEAD of frittering away his magnetism, Pacinotti showed how it could be concentrated, and thus he led the way to dynamos and motors becoming commercial machines. Pacinotti's science, engineered by Gramme, not only made electric lighting commercially possible. but led to electricity being used as a valuable motive power. It was in their work that the electric transmission of power in its modern sense sprang into existence.—*Professor Ayrton.*

OBITUARY.

Lucien Gaulard.

M. LUCIEN GAULARD, whose name is so widely and justly associated with the distribution of electricity by alternating currents and transformers, died on the 26th of November, at the St. Ann Insane Asylum, in Paris. M. Gaulard was born in 1850. His thermo-electric battery, exhibited in 1881 at Paris, first brought him into notice as an electrician. He gave much attention to the development of aniline products, and was the patentee of a process for tanning leather by electricity. But the significant feature in the work of his short life was the faith and energy which he devoted to demonstrating that electric energy can be transmitted over long distances by means of alternating currents and transformers. In England, the scene of his operations, it is admitted that, "from a practical point of view, the development of alternate current distribution was mainly due to his perseverance, energy, and enthusiastic belief in the capabilities of the system with which his name must ever be associated." Together with Mr. J. D. Gibbs, he began to develop his system, shortly after the Paris electrical exhibition. In his early proposals and undertakings he met not only opposition but ridicule at the hands of electricians. The recent complete success of distribution by alternating currents has completely justified his enthusiastic belief in the essential feature of his system; but it must be said that he persisted for a long time in a radically unsound method of applying it, viz., the joining up of an indefinite number of transformers in series. He did not take into account the counter electromotive force developed in each secondary generator. Experience was not lost upon M. Gaulard, and he was eventually convinced of his mistake.

Of the discourtesy, not to say disdain, heaped upon him in English electrical circles, let an English journal speak.—*Industries* says: "Many eminent electricians, who at that time ridiculed his ideas as almost akin to an attempt at producing perpetual motion, will now feel sorry that they did not take the trouble to investigate more closely the merits of his suggestions. Had they done so, they would easily have been able to divest his system from what was fallacious, and assist him to bring it to practical perfection. It is easy to find fault with a new and untried idea, and now that our conception of the dynamical principle involved in alternate current distribution has become clear, it is easy to point out at what particular point the early worker in this field erred; but six years ago the theory of transformers was not so well understood as it is now, and many electricians who ridiculed M. Gaulard's proposals at that time, could certainly not have helped him to carry them into practice, even had they been so disposed. Gradually, however, he succeeded in making converts. His exhibition at the Aquarium, and especially the trial at the Metropolitan railway, when a long circuit was worked from a central station at Edgeware road, caused electricians, to whom hitherto Ohm's law had been the beginning and end of their science, to think that after all there might be something in this new idea; and when M. Gaulard received the great prize at the Turin Exhibition of 1884, and was decorated by the King of Italy, the scientific world began to recognize his merit."

M. Gaulard's general plan of alternate current distribution has been taken up by many electricians and inventors in both Europe and America, and wrought out to complete success. The defeat of the Gaulard and Gibbs' patent in England, and the consequent loss of fundamental control of the new method of distribution, is said to have preyed heavily upon M. Gaulard's mind. It is, perhaps, to be regretted that he did not come to America where he won his greatest technical and financial success, and where the disappointments of his European career might have been assuaged by observation of the practical and commercial success that has attended the introduction of alternating current distribution by the American assignees of the Gaulard and Gibbs' invention.

.... THE engineer says distinctly: "Electricity is a form of energy—it is not a form of matter; it obeys the two great developments of the present generation—the mechanical theory of heat and the doctrine of the conservation of energy."—*W. H. Preece.*

.... IT only wants to be able to generate waves of any desired length in order to entirely revolutionize our present best systems of obtaining artificial light by help of steam engines and dynamos, which is a most wasteful and empirical process.—*Professor Ayrton.*

CORRESPONDENCE.

NEW YORK AND VICINITY.

Annual Meeting of the Medico-Legal Society.—The Julien Cars on Fourth Avenue.—Another Trial of the Daft Motor on the Elevated Road.—Surface Street Railroads Making Examination of Electric Traction Systems.—Suit Against the Holmes' Electric Protective Co.—Proposed Electric Road to Coney Island.—The City of Newark Investigating Police Patrol Systems.—The Daft Company in Newark.—The New Jersey and Perth Amboy Electric Light Co.—Mr. C. O. Mailloux.—A New Electrical Paper.

AT the annual meeting of the Medico-Legal Society, held at the Fifth Avenue Hotel on December 12th, a paper was read by Mr. Henry Guy Carleton (who writes funny articles for the *Sunday World*) upon the "Best Method of Executing Criminals by Electricity." The committee's report, recommending an alternating current of 3,000 volts, was finally adopted.

An electric locomotive designed for regular railroad service, weighing 15 tons and shaped like the ordinary steam railroad engine, is being built at the New York Locomotive Works at Rome, N. Y. The inventor is W. H. Darling, of Brooklyn, N. Y.

A marked advance has been made in the use of accumulators by the Julien Electric Traction Co. on the Fourth avenue line. The cars now make three round trips without change of batteries. The cost per car per mile is stated to be 2¼ cents.

Another trial of the Daft Electric Motor Car, "Benjamin Franklin," was held on December 5th. A train of eight empty cars was taken up a grade of nearly two per cent. at a speed of 7½ miles an hour. On two occasions a speed of 30 miles an hour has been maintained with three empty cars, without the slightest difficulty. The regular trains on the Ninth avenue line run at a speed of 13 miles per hour with four cars. The Daft Co. has maintained a speed of 15¼ miles per hour with four cars, and carrying a load of over half of the seating capacity of the cars.

While the increase of traffic on the elevated roads has been very heavy during the past year the surface roads, with one exception, show a decrease. This fact has made plain to the executive officers of several of the surface roads that an increase in earnings must be brought about by a decrease in operating expenses, and a quiet but searching investigation is being made into the various electric motor systems. It is rumored that several of the stockholders of the Sixth avenue line favor the adoption of the Julien system.

A suit for $25,000 has been brought against the Holmes' Electric Protective Co., by Mr. Geo. H. Holt, of 24 East 58th St., who alleges that he contracted with the Holmes' company for watchman's and burglar-alarm service, and that during his absence from the city last summer his house was robbed of jewelry, bric-a-brac, dresses, and other valuables.

An electric street railroad from Brooklyn to Coney Island is being agitated. General James Jourdan, president of the Kings County Elevated Railroad is said to be identified with the enterprise, and is looking into the various systems.

An explosion of gas in a conduit at the intersection of Maiden Lane and Nassau st., shortly after midnight, December 20th, has provoked the inquiry by the daily papers. "Is New York on a volcano?" An eye witness thus reports the accident:—

"The heavy iron cap of the man-hole was blown into fragments, which went hurling high into the air, followed instantly by a fountain of flame, spurting up ten or fifteen feet. This was followed by a suffocating belch of foul gases. Fully forty feet from the man-hole I picked up a piece of the iron cap that would weigh at least four pounds."

A sensational report has been passed about among the trade journals to the effect that Mr. Henry Villard had secured $10,000,000 from German capitalists for the extension of the central station business of the Edison company. It is not known that any officer of the Edison company has asserted this to be a fact. There is little if any doubt, however, that Mr. Villard has secured a large sum from a Berlin syndicate and has purchased large quantities of stock in the several Edison companies.

The *Herald* of December 21st claims to have foundation for asserting that the Villard syndicate have formulated a plan for the consolidation of the Edison and Westinghouse companies, and that interested parties are now in conference. Secretary Hastings, of the Edison company, is reported as saying that the Westinghouse people had been haunting Mr. Villard's office for a week past, offering to consolidate on terms which have not yet been agreed to. Mr. Geo. Westinghouse, Jr. was found in conference with several mysterious gentlemen at his branch office in this city. He is reported as saying: "We have more business than we can attend to, and that ought to satisfy any set of men possessed of reason."

The *Herald* asserts that the capital of the consolidated company is to be $80,000,000; $40,000,000 of the same to be good, ordinary, everyday water. A very pretty story.

Telegraphic communication with the Island of Hayti, now the scene of revolution and with which questions of state have arisen, has been entirely severed. Investigation reveals a fierce war between the French cable company, whose cable is the only one touching at Haytian ports, and the various other cable companies in the West Indies.

The new lines of the French company run from Santiago de Cuba to Mole St. Nicholas in Hayti, then along the Haytian coast to Puerta Plata, St. Domingo, thence by land to the City of St. Domingo. A cable is laid from there under the Caribbean Sea to Curacoa Venezuela, and from there to La Guayra. The company depends for an outlet to the United States and Europe on the West Indian and Panama Cable Co., whose lines extend from Santiago de Cuba to Kingston, Jamaica.

The Cuban Submarine Co. own a line from Santiago to Havana via Cienfuegos, Cuba. The International Telegraph and Ocean Co. own the cables from Havana to Key West and Punta Rassa, Fla., and control the one from Kingston to Porto Rico and running along the Windward Islands to Trinidad. The Panama company, however, operates both of these lines. This company, which is granted a subsidy of £2,000 per year by the Jamaica government, claims the exclusive right to land its cables on Cuban soil, and hence refuses to transmit messages to or from the French company.

Dr. Norvin Green, president of the Western Union, lays the blame upon the Spanish authorities, who refused to allow the French company to land its cables in Cuba.

President Geo. W. Plympton, of the electrical subway commission, Brooklyn, has handed in his, report for the year ending November 30th, 1888

These are the main points presented in the report. "The aggregate length of underground conductors has been increased from 1,433 miles to 2,928. There are still 5,111 miles of aerial conductors. Those of the various district telegraph companies and of the Gold and Stock Telegraph Co. are on housetops, and not poles, and the board has continued to permit them to operate above ground. Of the 4,402 miles of telegraph and telephone wires, more immediately the subject of the operations of this board, it is reasonable to expect that nearly all of the 236 miles of telegraph wires now carried on poles will be removed. Of the remaining 4,176 miles of telephone wires, a considerable proportion is required for terminal distribution in connection with the subway system; another large part will be removed from poles within the next few months, and much, if not the greater part, of the remainder is so distributed that it is not practicable at present to combine the separated wires in cables.

"The elements both of advantage and of difficulty vary so widely in different cities that comparisons based on wire mileage alone are too superficial to be either just or useful. This board does not claim, therefore, special credit for the fact that the actual increase of underground mileage has been considerably greater in Brooklyn during the past year, than in any other city.

"There have been removed 225 poles, carrying over fifty miles of wire. This includes all the poles on Broadway, and nearly all those on Fulton and Myrtle avenues, from which the few poles now remaining will shortly be removed. There are about eighty miles of overhead electric light wires remaining, and more than half of these will be transferred to the elevated railroads at an early day. When this shall have been done four-fifths of the poles and wires of this class will have been removed.

"But satisfactory as this result may be, and great as is the relief thus afforded to business streets, the problem of electric arc light distribution will not thereby be solved for the future. For the most serious features of the situation, as all who have undertaken to deal with it have been compelled to admit, is the immense rapidity with which the use of electricity, particularly as transmitted in the form of currents of high tension, is extending. The perfecting of a practicable and safe subway system is still called for, though at the present moment the need of such a system is more imperative in other cities than in Brooklyn.

"The electric lighting companies have during the past year leased the right to place their wires upon the elevated railroad structures of the city; and, since these structures occupy the principal business streets, such as Fulton and Myrtle avenues and Broadway, where the larger part of the electric arc lighting is done, the arrangement has proved specially favorable for the rapid removal of poles and aerial conductors of this class."

The New York aldermen have finally granted permission to the Fourth avenue road to use electric motors. The only argument brought to bear against the ordinance, was that the street railway company would not consent to pay into the city treasury a certain percentage of its gross receipts as the Fulton street company agreed to do, while it was claimed a very large decrease in operating expenses would be effected. New cars are now being built by Messrs. Brill, of Philadelphia, and will take the place of the horse cars as fast as equipped.

The work of laying the Bentley-Knight conduit on Fulton street has already begun, and attracts throngs of people daily.

The patrons of the Casino theatre on Christmas Eve were surprised by noticing boxes attached to the backs of the new opera chairs, upon which an announcement could be read that by dropping a quarter in the slot, a pair of opera glasses would be furnished for the evening's entertainment. An electric device gives notice on an annunciator of the removal and the return of the glasses. This system will soon be placed in the Fifth Avenue, and other theatres.

The police commissioners of Newark, N. J., are investigating police patrol signaling devices, with a view to the adoption of a system for that city.

The Essex Passenger R. R., of Newark, has received permission to erect poles and wires in order to give the Daft Co. an op portunity to demonstrate the advantages of its system.

The New Jersey and Perth Amboy Electric Light Co. was organized some months ago by Messrs. Seabury and Johnson, of No. 18 Cortlandt st., and construction has already begun for an arc and incandescent system.

Mr. C. O. Mailloux, the well-known electrical engineer, has taken charge of the electric power department of "*Power-Steam*," a monthly steam engineering paper.

Mr. Ralph W. Pope, secretary of the American Institute of Electrical Engineers, and Mr. George H. Stockbridge, formerly manager of the patent department of the "*Electrical World*," announce the publication of a new electrical journal devoted to the electric power interests.

NEW YORK, December 29, 1888

PHILADELPHIA.

A Suit Against the Consolidated Electric Light Company.—The Keystone Company's Franchise.—Lights for the New City Hall.—General Permission to Run Electric Service Pipes.—The New Western Union Office in the Rotunda of the Post-Office.—Extension of Electric Street Lighting.

Walter and Stuart Wood, of this city, have secured judgment in the United States Circuit Court in New York for $18,550 against the Consolidated Electric Light Co., being the principal and interest on $17,500 worth of bonds held in the defendant company. The complaint was that interest had not been paid.

When judgment was entered the company answered that forged and fraudulent bonds had been issued, and that to secure bondholders a new issue had been made, exchangeable for the original bonds, and that the complainants had not exchanged their bonds. The complainants entered a demurrer to the sufficiency of the answer, and were supported by Judge Wallace.

The electrical sub-committee of councils having under advisement the granting to the Keystone Electric Light and Power Co. the privilege to lay conduits and wires in certain streets, reported to the committee proper that they had decided to report favorably. The city solicitor, who was asked his opinion, said that the board of highway supervisors, the company and himself were satisfied with the provisions of the supplemental ordinance granting these privileges, and there was to him no apparent objection to giving the right. The ordinance, like all others granting privileges to electric light companies, provides that the company shall give the city, for municipal purposes, the use of one duct or three working wires. The bill will be reported favorably to councils.

An ordinance for an appropriation to put lights around the new city hall was referred to the finance committee.

Councils have authorized all electric light and power companies to introduce electric service pipe into stores, dwellings and all kinds of public buildings between December 1, 1888, and March 1, 1889, upon the payment by the companies of $5 for each permit to open streets during the period named.

The Western Union Telegraph Co. have opened a new office in the rotunda of the post-office here with thirty-eight wires in full operation. A full district messenger service has been organized, and the office will be open night and day. Every convenience has been provided. By a signal the wires of the main office can be switched on, and all parts of the country reached. The wires at the post-office are all underground.

Diamond street, from Broad west to the park, is to be lighted by electricity. Diamond street is a splendid thoroughfare, and with the electric lights in operation will present a very handsome appearance. The distance to be lighted is about two miles.

PHILADELPHIA, December 18, 1888.

BOSTON.

Sulphureted Hydrogen in the Conduits.—The Underground Franchise.—Damage to the Nantucket Cable.—The Long-Distance Telephone System.—The Telephone Suit.—Mr. Leonidas Le C. Hamilton's Course of Lectures.—The West End Street Railway Co.: A Part of the Electric System Tested.—The Monthly Statement of the American Bell Telephone Co.—New Corporations.

STRANGE to say, putting the electrical wires underground does not put them out of mind. It was thought by some of our good citizens that when the wires were all buried peace would prevails

but they find that even then they "will not down."

Scollay square, Brattle street and Cornhill have for a long time been afflicted with an obnoxious odor, and a petition signed by the business men has been addressed to the Board of Health, setting forth that, through the operations of an electric company, in pumping a foreign substance into the conduits, the premises of the petitioners have become seriously infected and the health of many persons endangered. To prevent the destruction of the lead pipes enclosing the wires, by the action of the acetic acid in the creosote, with which the conduits have been treated, the company have pumped sulphureted hydrogen into the wooden ducts.

The general impression is, that the corporation who have obtained rights for underground conduits in this city, over the opinion of the city solicitor and the vetoes of the mayor, will not do much business other than selling stock, for some time to come. In fact there does not seem to be much room for such a corporation to do work, as the telephone company and the Edison people have their wires down, and the arc light companies are not being forced underground anywhere, so far as known.

Lieutenant Wright, of the Signal Service, who has investigated the damage to the Nantucket cable, says that the seas that came in on the southern portion of the island were the most dangerous of very many years. They washed away about 200 yards of the beach and cliffs three miles below the Surfside life saving station, and carried away the cable box in which the connection was made with the cable and land line. The cable comes in at that point from Martha's Vineyard, and the link in the system is a vital one. Not only did the sea take possession of the cable box, but it washed down two of the poles carrying the land line. The sand was being deposited over the cable bed to the amount of thousands of tons, and Lieutenant Wright saw that a great loss of property would occur if he did not lift up the end of the cable at once. He sent a gang of men off shore a third of a mile, where the line was, who grappled for it. It was raised, and is now buoyed there, so that when the work of restoring the connection is begun, the inshore end will probably be raised without much difficulty. When a similar mishap occurred at Block Island some time ago, it took 16 yoke of oxen to pull the heavy wire out of the sand into which it had become imbedded. The work is hazardous, on account of the tremendous undertow that exists there, and to prevent any loss of life, the Surfside life savers have agreed to remain on shore close by the end of the cable, ready with a Hunt gun to lend assistance if it should happen to be needed.

Every innovation, whether in the modes of conducting business or in other respects, is progressive in this age, and no novel device has been more marked for rapidity of improvement than the telephone. From short-distance communication, which was at first considered a marvel, audible conversation can now be carried on with ease over wires hundreds of miles long. New York, Buffalo and intermediate points were opened up to representatives of the press yesterday, not as an experiment, but to show the practicability and usefulness to the business and social public of a system that has been for some months in successful operation. It has been brought to a positive certainty by auxiliary appliances that have borne severe tests. The American Telephone and Telegraph Co. has its lines in perfect order. The main office is situated at 53 Devonshire street. In a little closet at one end of the room is a table from which projects a steel arm, having upon its end what appears to be a common speaking tube. In talking, one must hold his mouth well into the transmitter, instead of a short distance away, as in the ordinary machine. After talking with Providence, New York and other distant places, the operating room at 215 Franklin street was visited. Here four operatives are engaged in making connections with the different points. All the connections are kept upon slips, which are turned into the central office every night. Upon these slips are put the time of connection, time consumed in talking, and the number or name of the person sending the message. The first public station is at 42 Summer street. The telephones are in closets, which are built double to prevent sound entering. The upper part is of two thicknesses of plate-glass, over which curtains are hung. The inside is lined with embossed leather, which gives the room a very handsome appearance. At the Adams House is another station. Here are two "booths." The attendants are in uniform. Another station is at No. 50 Pearl street, which is largely used by the business men of that section.

The popularity of the long-distance telephone is rapidly increasing, and more stations will doubtless soon be needed.

United States District Attorney Galvin, on the 10th inst., filed in the United States Circuit Court an amendment to the bill in the suit of the United States *vs.* the Bell Telephone Co. The amendment sets up the Drawbaugh patent. The case was brought up in the Circuit Court on the 12th inst., and it was stated by Judge Colt that the United States Supreme Court had overruled the defendant's demurrer; therefore he ordered the defendant to plead or answer the complaint, or do both, within 60 days.

Mr. Leonidas Le Cenci Hamilton has been delivering a course of lectures in Horticultural Hall, upon "Electricity and Magnetism" and kindred subjects, illustrating his theories concerning the nature of all forces.

Before the board of aldermen, on the 26th ult., an order was passed granting the West End Street Railway Co. the right to lay down tracks on Harvard Bridge, beginning at the line which separates the city of Cambridge from the city of Boston on Harvard bridge, thence on the bridge and West Chester Park to Beacon street, to connect with tracks on Beacon street.

The same company was authorized to maintain the electric system of motive power in the operation of its cars, by the overhead system, between West Boston bridge and Bowdoin square. A letter was received from Mr. Henry M. Whitney, president of the company, agreeing that if the conduit system proves successful he will substitute a conduit for the overhead system.

A part of the West End Brighton line of railroad which has been fitted for overhead electric propulsion of cars, was tested on the forenoon of the 4th inst. The engine in the power house at Allston was started up, and five minutes afterward the car left the Oak square stable with five persons aboard. The climb up the hill was made easily, and from there to Harvard street, Allston, the run was made without event, the car reaching a speed of 16 miles an hour. On Harvard street, near the Hawthorne turnout, the track was covered with dirt, and it was almost impossible to move the car, as no connection could be made through the rail which is a necessity. While experimenting here with one motor, something went wrong which caused the burning out of a switch box. But this did not delay the car, as it is so arranged that it can be run from either end. On the return trip, near the corner of Cambridge street, the car in taking a switch jumped the track, all four wheels leaving the rail. It was but the work of a few minutes to run it on the rail again, and this without apparent effort. Twelve cars are already fitted up ready to run. They were built by the Newburyport Manufacturing Co., are lighted by electricity and painted a robin's egg blue. They are lettered "Beacon Street, Brookline," and "Brighton via Boylston street and West Chester Park."

The output of telephones by the American Bell company for the month ended November 20, and the year to date, with comparisons, is reported as follows :—

November--	1888.	1887.	
Gross output	3,861	4,330	Dec. 469
Returned..........	2,452	2,667	Dec. 215
Net output..........	1,409	1,663	Dec. 254
Dec. 21 to Nov. 20—			
Gross output....................	49,661	48,670	Inc. 991
Returned	21,399	24,695	Dec. 3,296
Ne. output.	28,262	23,975	Inc. 4,287

Lenox Gas and Electric Co., capital $30,000. W. R. Plunkett, president; C. E. Merrill, treasurer; W. R. Plunkett, Alex. Kennedy, T. T. Robinson and R. D. Wilson, directors.

Lee Electric Co., capital $15,000. Wellington Smith, president; David Dresser, treasurer; the same and T. T. Robinson, directors.

The Dedham Electric Light Co. has been incorporated, with a capital of $25,000; John A. Bullard, president, Ferdinand F. Favor, treasurer. Also the J. W. Bailey & Sons' Co. of Boston; capital $20,000; Edward S. Bailey, president, Willard L. Bailey, treasurer.

BOSTON, December 17, 1888.

CHICAGO.

Effect of the Victory of the St. Louis Telephone Company.—Further Stages of the Controversy in Chicago.—Hundreds of Business Men Protest Against the Unsettled Condition of the Affair.—A Bitter Contest for the Street Lighting Contract at Elgin, Ill.—Annual Reception of Railway Telegraphers.—Installation of a 10 h. p. Sprague Motor.—The Coming Electric Light Convention; Extensive Preparations for Exhibits.—The Inter-State Telephone Company Summarily Enjoined.—Street Railway Notes.—A Phonograph Company.—Personal Mention.—Trade Notes.—The City Lighting Plant Started Christmas Day.—Detroit Storage Batteries in Professor Gray's Laboratory.—The Chicago Electric Club.

THE decision in the St. Louis telephone case was received with the greatest interest in Chicago, and the officers of the telephone company were in a mood that was almost hilarious. Had the decision been against the St. Louis company it would have been considered a precedent. The Chicago city council in all probability would alone have imitated the St. Louis aldermen. The telephone officers claim the decision will practically put a stop to the movement in Chicago, which was aimed at securing a reduction of rates, and they were eager to talk of the situation. F. H. Winston, attorney for the company, who has conducted the proceedings in the controversy here, said: "We do not anticipate any further trouble in this city. I consider the whole question settled. The City of Chicago will not attempt to re-open a fight without any ground upon which it can stand."

"But suppose the city secures the power to regulate rates from the legislature?"

"Then we shall probably follow the course pursued in Indiana. You know that we ceased operations there. We will do the same

thing here and leave Chicago without telephones. If the people of this city want to be unreasonable they shall be obliged to take the consequences. No other telephones can be operated. That too has been decided. We have the situation in our own hands. We are willing to do what is just and reasonable, but we shall demand the same treatment at the hands of the city."

Judge Green, the corporation counsel, was deeply interested in the result. It will be seen that the position assumed by him has been sustained in every respect. He is, of course, naturally elated over this fact. When questioned as to the probable course of the city in the matter, the legal adviser of the city hesitated a moment, and then said: "Well, I don't know exactly what we can do just now." The tone of his voice indicated that he shared the feeling of the city council and members of the anti-telephone committee that the company had won a great victory and was in a firm position. That is the general impression, and conservative business men think the best thing the council can do is to come to an understanding with the company.

The progress of the controversy is noted in the following brief report of meetings of the city council and its finance committee. In the early part of the month when the finance committee of the council commenced anew their attempt to solve the telephone problem, they found their way blocked. The committee rather expected to recommend an ordinance reducing subscribers' rentals in imitation of the St. Louis act, but an opinion of corporation counsel Green was received stating that this right did not vest in the council; that an appeal to the legislature for a grant of the desired authority must be made. At the next meeting of the committee, a proposition was made on behalf of the telephone company, offering by way of compromise the free use of instruments for municipal offices, for fire department and police department sets at nominal figures, and 2½ per cent. of its gross receipts. In return, the company asked for the right to extend its wires and to operate its system without threats of vexatious litigation. Representatives of the druggists, liverymen's, and undertakers' associations were present, and protested against the acceptance of any ordinance which did not provide for the reduction of charges to subscribers. On the day following, the company served on the mayor notice, that in the future applications would be made in the name of the Bell Telephone Co., to which a franchise had originally been granted, but which the council holds is void on account of non-use.

At the next meeting of the council, a resolution was adopted instructing the commissioner of public works to refuse all applications asked for in the name of the Bell company.

At the council meeting, December 15th, four hundred business men were present to protest against further delay in settling the question, but no action was taken.

An unusually bitter fight has been waged over the contract for lighting the streets of Elgin, Ill. Charges of bribery and corruption have been numerous, and have been made against both the aldermen and representatives of electric light companies. On December 8th, the contract was awarded to the Jenny Electric Co., of Indianapolis. The action was not legal on account of technicalities, and it was decided to re-advertise for bids.

The Railway Telegraphers of Chicago, gave their annual reception December 6th.

The Sprague Motor Co.'s western office has installed a motor in the rooms of the gold and stock department of the Western Union Telegraph Co. It is of 10 h. p. capacity. The motor runs two Edison dynamos, the current of which is utilized in running the tickers and for lights. Current for the motor is supplied by the Edison circuit.

The executive committee of the National Electric Light Association proposes to make the Chicago convention notable in the way of exhibits. A large hall will be hired for the purpose of displaying inventions of all kinds.

Judge Blodgett, in the United States Circuit Court, has refused to give the Inter-State Telephone Co. further time to prepare its defense to the charge of infringement preferred by the Bell company, and has issued an injunction restraining it from further operation.

The Topeka Electric Road, which the Thomson-Houston company is equipping, will be 16½ miles in length. The same company has taken a contract for extending the electric road at Wichita, Kans.

The Illinois & Indiana Phonograph Co., of Chicago, has been incorporated by Green B. Raum, Frank Z. Maguire and Joseph Kirkland. The company will operate in Indiana and Illinois, having secured the exclusive license to rent graphophones and phonographs in these two states. The company exhibited for several days the instruments in a hotel parlor where they attracted no little attention.

Mr. E. M. Barton, president of the Western Electric Co., left Chicago for Europe some weeks ago and will pass the holidays with his family in Berlin. Mr. Charles S. Scribner, electrician of the same corporation, is in Antwerp, at the headquarters of the Western Electric Co. in that city.

Mr. B. E. Sunny, the president of the Chicago Arc Light & Power Co., has taken a position in the Chicago office of the Thomson-Houston Co. He still retains the presidency of the former corporation. C. H. Wilmerding has been appointed superintendent of the Chicago Arc Light & Power Co.

Conant & Hood will hereafter represent the New York Accumulator Co. in Chicago. They have succeeded to the business of the Northwestern Accumulator Co.

The city electric light plant was put into operation for the first time on Christmas Eve, and for the first time in the history of Chicago the central part of the city was brilliantly illuminated. The principal streets in the business district on the south side are lighted, and on the west side the lights illuminate Madison street for two miles. The central station is located on Jefferson street, near Van Buren. The dynamo room contains 16 Western Electric 35-light generators. Power is supplied by a 400 h. p. Wright engine. Only 300 lights are utilized at present. The system will be extended from time to time. The fact particularly insisted upon by city electrician Barrett, and Chicagoans in general, is that this system is the largest underground plant owned by any city in the world. The cables end in a Western Electric switch-board, so arranged that any dynamo can be connected on any circuit in a few seconds. The dynamos are not connected in series, but each supplies its own circuit. The circuits are so laid out that the potential can not be higher than 1,000 volts. The system has given thorough satisfaction, and there are already plans suggested for extending it considerably. There is talk of employing the tax which the aldermen hope to obtain from the telephone company in extending the system.

At Professor Gray's laboratory in Highland Park, there is a new installation of Detroit storage batteries. They are charged by current from a 40-light United States company's dynamo. The accumulators supply current for lighting the professor's house and in illuminating the laboratory when the generator is not in operation. It is proposed also to light the Presbyterian church in the same way. The batteries are considered the reserve force of the laboratory. If the engine should break down the dynamo can be employed as a motor deriving its supply of current from the cells. Professor Gray says his telautograph will be put into commercial use in the spring.

At the next meeting of the Electric Club, January 7th, the members will discuss the subject of insulation. At the last meeting Dr. George W. Whitefield presented a paper treating of the evil results attending the use of dissimilar metals as filling material in the mouth. He demonstrated by a galvanometer that the employment of amalgam and gold filling would cause the generation of an electric current, the effect of which would be destructive.

CHICAGO, December 22, 1888.

MONTREAL.

The Lachine Rapids to be Utilized.—Proposals for Lighting the City.—The Police Ambulance System.—The Suit of the Royal Electric Co. vs. Edison Company.—Recent Sales of Lighting Apparatus.

YOUR readers, doubtless, have heard of the Lachine Rapids, and many may have had the pleasure of a trip down its raging waters. Only by such a trip can one fully appreciate its force.

Several years ago a charter was obtained with power to develop the natural force now uselessly expending itself at the rapids; but only recently has there been any active preparation toward a utilization of the magnificent power obtainable there.

A syndicate has, however, purchased the Isle au Heron, situated at the head of the rapids, and through which there is a natural channel. This company propose to deepen the island channel and build breakwaters, thus directing a large volume of water through the works from which, it is estimated, 250,000 h. p. can be obtained. The island is some distance from the main land, and about seven miles from Montreal. The power developed will probably be transmitted to Montreal by the electric method and there converted into light and power.

The proposal that the city do its own lighting, mentioned a month ago, has led to an animated discussion, both in the council and public prints. The Royal Electric Co. have a contract with the city with three years to run. They propose to terminate the contract and make a new one for ten years at 42½ cents per lamp. They are at present paid 60 cents per lamp. The Edison company made a counter proposal of about 32 cents per lamp. The Canadian Electric Light Co., who propose to operate from the Rapids, have made a proposal of 30 cents per lamp, less than either of the former proposals.

The Royal company now come forward with a proposal of 40 cents per lamp under limitations; as the Royal contract is exclusive, they will probably do the lighting.

The Toronto Electric Light Co. have recently proposed to terminate a contract with two years to run, and to light the city of Toronto at 35 cents per lamp per night.

The ambulance system is now so universal an adjunct to a complete Police system it creates considerable astonishment to have a Canadian city lay claim to having first inaugurated it. However, chief Davidson, of Sherbrooke, says his system was in operation August 12, 1882.

The hearing of the Royal Electric Co., Sawyer-Man, and others, *vs.* the Edison company, before the Commissioner of Patents, for the annulling of the Edison patents, has been finished. The commissioner, however, reserves his decision.

The Sherbrooke Gas and Water Co. have purchased two Royal and two Ball arc machines, and will do electric lighting in addition to gas lighting.

The Edison company report Chatham, N. B. central station, 300 lights; Gazette Printing Co., Montreal, 1,050 lights; Cornwall M'f'g. Co., 450 lights; C. P. Ry. Steamer New, 225 lights; C. P. Ry., Alberta and Athabaska, increase 60 lamps each. Brandon, Manitoba central station, 450 lamps; Moody and Sans Terrebonne, Que., 150, and Connell Bros., Woodstock, 300 lamps; Intercolonial Ry., Moncton, N. B., 450; Pembroke Electric Light Co., central station, 1,000 lights.

The Royal company report 25 arcs, River du Loupe, Que.; Cumberland Coal and Ry. Co., 15 arcs; St. Catherines, increase of 35 arcs; Geo. T. Davis, Levis, Que., 15 arcs; Winer, McKichnie & Co., Granby, Que., 50 incandescents; Vancouver Foundry and Mach. Works, 50 incandescents. Their alternating system is in operation, and among other installations are 500 incandescents in the City Hall.

The Edison company report in addition to the large sales made by them, the sale of an electric road (Sprague system) 5½ miles of track, 5 cars, at Vancouver, B. C.

MONTREAL, Que., December 19, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall street, New York city.*

AN UNARMORED SUBMARINE CABLE.

[101.]—I have read with interest the letters of Mr. David Brooks and "W. M. C." in your November and December issues upon underground and submarine cables. In connection therewith it may interest your readers to know the details of the manufacture of a submarine cable now being made in this city by the Bishop Gutta Percha Company, said cable being made according to specifications furnished by Capt. Samuel Trott, of the repairship *Minia*, and Professor F. B. Hamilton, electrician of the Anglo-American and Direct Cable companies.

The stranded copper conductor is first insulated with gutta-percha, then sewed with soft hempen yarn saturated with tar, then with an armor of harder twisted hempen yarn. In order to give the cable weight and stability the interstices between the threads of hempen yarn, as also between the two layers are filled with a compound of mineral pitch and silica, and a heavier coat of the same compound is put upon the outside by running the cable through dies prepared for that purpose. The silica compound serves to "weight" the cable and protect it from the attacks of the teredo.

The usual iron armor is entirely dispensed with. In all of the deep sea cables the iron covering has been found to be badly deteriorated, while in cables which have been under water for more than twenty years there has been no appreciable change in the tarred hemp bedding or the gutta-percha insulation.

Experiments recently made show that the iron armor is unnecessary, and that cables can be made lighter, cheaper and more durable without it.

The cable we are now making ,forty miles in length; will connect the Islands of the Sandwich group in the Pacific Ocean, and we understand that an English company has decided to lay the same kind of cable from Vancouver, British Columbia, to the Sandwich Islands, thence to New Zealand, thus completing the electrical circuit of the world.

HENRY A. REED.

DR. ATKINSON'S "ELEMENTS OF ELECTRIC LIGHTING."

[102.]—I am informed by the publisher of my recent work, "The Elements of Electric Lighting," that various English publishers propose to prohibit its sale in England, on the ground that it contains matter appropriated from English electric works published by them.

As I have always had such contempt for plagiarism, that I seldom even quote from another writer, preferring to use my own phraseology when adopting the ideas of others, I was much surprised to learn that such a charge had been made, and must infer that it is not possible that any of these gentlemen can have carefully read or examined my book. A charge of theft, literary or otherwise, "cannot be sustained till the property is found in possession of the thief and identified," and the burden of proof rests upon those bringing the charge. My work is before the public, and no one can show a single line which I have appropriated from any other writer except in my summary of installation rules, pages, 254 and 255, which I do not claim as my own. I found these rules given in common by different writers and modified them to suit my purpose.

In my chapter on the storage battery I adopted the theory of Gladstone and Tribe, using my own phraseology, and giving them full credit, both in my introduction and on page 218.

As stated in my introduction, I consulted the works of several different writers, mentioned my name, and embodied in my own language, modified by my own ideas, such matter as I found adapted to my use. This I understand to be the privilege of every writer. No scientific writer can claim to be wholly original; his writings are necessarily based on information derived from others whose ideas have become incorporated into his own body of thought. And as the object of a book like mine is to give the latest and most reliable information obtainable on the subject and not merely one's own peculiar views, I not only consulted other writers but made a thorough practical examination of the various kinds of apparatus described and the principles of their operation; visiting factories and inspecting machines and apparatus in the various stages of construction; conversing and corresponding with inventors and manufacturers; examining patents, and by every possible means seeking full and accurate information on every point.

My illustrations were obtained from various sources; some from books, pamphlets and periodicals, others from cuts lent me by patentees and manufacturers, and others from my own drawings; most of those from outside sources requiring modification to adapt them to my use. Some of these illustrations are the same as those found in English books, and yet even these are, in many instances, identical with those from cuts lent me by American manufacturers, while others are found in common in various electric works; so that I had no evidence that any of those copied from English works were from original drawings designed for any particular book; indeed the authors themselves acknowledge that their illustrations were in part obtained from outside sources; hence I have only followed the common practice of others by copying such illustrations as I found adapted to my use, for which, in my introduction, I have given full credit.

English electric books have had a large circulation in the United States, and common courtesy would seem to require that my book should have the same opportunity for circulation on its merits in England.

PHILIP ATKINSON,
168 Randolph St.,
Chicago, Illinois, U. S. A.

November 30th, 1888.

LITERATURE.

REVIEWS.

Traite de Télégraphie Sous-Marine. Par E. WÜNSCHENDORFF, Ingénieur des Télégraphes, Directeur de Télégraphie Militaire (469 gravures dans le texte). Paris Librairie Polytechnique, BAUDRY ET CIE, Editeurs, 1888. Large octavo, paper, 556 pp.

FIRST NOTICE.

THIS treatise consists of the series of articles on submarine telegraphy, contributed by M. Wünschendorff to the pages of *la Lumiere Electrique*, during parts of 1887 and 1888, with slight rearrangement and a few additions, the latter intended to bring the work abreast with the latest developments in apparatus.

Although it is but thirty years since the first Atlantic cable, in its few weeks of use, demonstrated the possibility of realizing what the incredulous called the dreams of Frederic N. Gisborne and Cyrus W. Field—not to mention earlier believers and workers—and little over twenty years since commercial success was attained in establishing telegraphic communication between the old and new worlds,—although ocean telegraphy is of so recent date and has reached such enormous proportions as an industrial art—its familiar use and the diversion of popular interest to still more recent electrical developments, the telephone, electric lighting and transmission of power, have somewhat lessened its hold upon the attention of the public, and of electricians as well. Amidst, therefore, the whirl and din prevailing in electrical circles at present it is agreeable and restful to take up M. Wünschendorff's book, to read afresh the story of submarine telegraphy, from the suggestion of it which the author finds in Sœmmering's firing gunpowder at a distance at St. Petersburg, 1807–1808, and at Paris in 1813 through a submerged wire, through its gradual development in crossing the channels and seas of Europe up to the successful establishment of an Atlantic line, and the subsequent completion of the magnificent chain of cables connecting all the continents of the world.

Part i, some fifty pages, is devoted to the historical sketch above referred to. Parts ii, iii, iv and v treat, in their respective order, the composition and manufacture of submarine cables;

laying and repair; electrical testing, the discovery of faults; and the working of submarine lines. In its scope the volume reaches over the entire subject of submarine telegraphy, and so far justifies its title, "A Treatise." The work will be of interest and usefulness to general readers through its very full exposition of the processes and methods of so important an art as ocean telegraphy.

British names necessarily predominate in any general account of cable manufacture, promotion or operation; and the part which English genius and enterprise have played therein is exhibited in every part of M. Wünschendorff's book from the preliminary historical chapter to the end.

The work is copiously illustrated; the engravings are clear in their intention and fairly good, although not handsome.

In the chapter on signaling apparatus we miss any mention of Mr Charles Cuttriss's modification of the siphon recorder.

A CALENDAR WORTH HAVING.

CALENDARS of the complimentary-commercial variety, received in such abundance at this season, that it is impossible to mention or acknowledge them all, are usually handsome and often artistic in appearance, but seldom possess such valuable literary features as are found in the calender for 1889, just issued by the American Electrical Works, Providence, R. I. Heretofore, Mr. Phillips has often adorned his yearly reminder with dainty engravings of more or less (usually more) attractive objects; this year he goes a step further, giving on each weekly leaf of the calendar an apt quotation and a number of references to historical incidents the anniversaries of which fall within the week. The quotations are from writers of all periods, including some from the Hebrew scriptures, and relate either directly or indirectly to electrical science or the arts founded upon it. The historical memoranda, some 200 or more in number, include the dates of the notable events in the course of electrical development, from the earliest notices of the existence of the mysterious force to the modern applications of it in the arts of the world. Both quotations and notes have been prepared by a skillful hand directed by a nimble wit, and they are not less entertaining than useful. The compiler has made use of much out of the way information, and supplies many facts and dates not readily accessible to the general reader or student.

The calendar will doubtless be much sought for. It is well worth careful preservation for occasional reference.

RECENT PUBLICATIONS.

The Alloys of Aluminum and Silicon Produced in the Cowles Electric Furnace and their Use in the Arts. *The Cowles Electric Smelting and Aluminum Co.* Lockport, N. Y.: 1888.

Etude Theorique des Transformateurs, Détermination par la Méthode Graphique de Curs Éléments de Fonctionnement Par Charles Jacquin. Paris: *G. Masson*, 1888. 8vo., paper, 27 pp.

Die Accumulatoren fur Elektricitat. Von Edmund Hoppe. Berlin: *Julius Springer*, 1888.

NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF DECEMBER 18, 1888.

THE Institute of Electrical Engineers met at the College of the City of New York, Tuesday evening, December 18. The meeting was called to order by the secretary, Mr. Ralph W. Pope, and, on motion, Mr. Geo. M. Phelps was chosen as chairman for the evening.

As previously arranged and announced, the session was devoted to a paper by Mr. W. J. Jenks, member of the Institute, director of the standardizing bureau of the Edison Electric Light Co., on "Six Years Practical Experience with the Edison Chemical Meter." (For Mr. Jenks's paper, see page 7.)

DISCUSSION.

The Chairman—I am sure the Institute is to be congratulated on the lecture this evening, and that we should be very grateful to Mr. Jenks for the pains he has taken and the elaborate preparations he has made, and for having given us a great deal of information, which probably few, if any, of us had, as to the practical experience with these electrolytic meters. It seems a very good practice, promising well for the future, that men who actually know about these things, and can therefore tell us all about them, should come before us and tell just what has been found out about them through experience. The subject is now open for discussion.

Mr. Jenks—I would like to say a word just at this time. It certainly is a good practice to bring people who handle devices of this kind into such a position as will enable them to tell what they know about such devices; and my regret, to-night is, that for several years, I have not done anything in the way of practically handling the Edison meter. I am not a chemist; and have, in a measure, gotten out of the way of handling or remembering figures and exact quantities about which you might ask me a great many questions that I should not be able to answer off hand. I have undertaken to show the practical results attending the operation of the meter, and any question in that line, as well as in others, that I chance to know about, I shall be very glad to answer.

Mr. C. S. Bradley—I would like to call Mr. Jenks' attention to the fact that he did not fully summarize the smallness of the error due to the comparative resistance of the bottle and spool, combined with the shunt. The ratio being as 975 to 1, there is a very small error.

Mr. R. W. Pope—I feel that I may congratulate myself somewhat, on being responsible for bringing up this subject. It was originally my desire to have some one take up the whole meter question, and go through it exhaustively, showing the work of different inventors. When I made this suggestion, I had no idea of the practical perfection attained in the Edison meter, nor of the multitude of devices which the inventor had brought out before arriving at the perfected form now shown us. We have seen that Mr. Edison has utilized the various properties of the electric current in many different and very ingenious ways. Many of these experimental meters may not be practical; but I am sure they all tend to show remarkable fertility of invention.

It has been very interesting to compare the experience in electric meters with those used for other purposes which have had discredit thrown upon them (and I think—rather unjustly). I have had some experience with the gas meter, and I must say, that I have always found it very accurate. I used to read one in the Western Union building. True, it was not used very much in the summer, but it ran on for four or five months, and the bill would come in for perhaps 25 cents. Once in a while the bill would be larger than the average and upon investigation I would find that some one had been working at night. I have a meter in the Institute office, and frequently use gas on dark days. My bill for six months was $1.47—not very exorbitant. There is an important point about the electric meter. It is going into a field where there has been nothing of the kind before, and that is power service. All power service is now furnished under contract, so much a year, or so much a month per horse-power; but there is always a question whether a man gets 6 h. p. or 10 h. p., whatever the understanding may be, and many judge by the width of the belt, and the tightness of the belt, as to how much the customer is taking. Then again, a man may pay for 6 h.p. in one day and not use it at all. In printing offices the presses may be idle all day, but they have to pay for their power all the same. In this field a meter should prove a very desirable instrument, and relieve the minds of many consumers as to the amount of the bills they ought to pay. Then in domestic service, we can all see the benefit of using a meter. For a residence, the contract service will not answer at all. So far as I know, the contract price at which incandescent lamps are put out precludes their use in private families, where that light is most desirable.

I could not help thinking, when I saw the pictures thrown upon the screen, as they passed one after the other, what a long road Mr. Edison had traveled over, and how much trouble he might have saved, if he had only permitted himself to be guided by the experience of John Gilpin, who rode through Cheapside,

> And hung a bottle on each side
> To make his balance true.

Mr. Edison has got his meter down to two bottles, and we have been shown to night that the instrument is true.

Professor E. L. Roberts—I would just like, if Mr. Pope will allow me, to take one of his remarks as a text, for a moment. It was about the gas meter. We had an electric light company in Cheyenne, and I blackguarded the gas meter with all my power. Then, we bought up the gas company. I had to send bills to the gas people, and the customers remembered it, and it was a difficult thing to get out of. When I went to prove up the meters, one of them registered in favor of the company; nearly everyone was in favor of the consumer, about three per cent., and some considerably more than that. As the tendency of the electric companies is to buy up the gas companies, and not the gas companies to buy up the electric light companies, it is not advisable for any man to get into that fix, if he can possibly help it. I would like to ask the lecturer if there is any basis as to the length of time to weigh up and do all the registration necessary, say, on 100 meters—the time required to do the manipulation necessary to arrive at the figures.

Mr. Jenks—I think, perhaps, a fair approximation to that may be reached by the averages which were given on the number of meters per station, and the average expense. The number of meters per station on an average, in 18 stations being 225, the average expense being $4 per meter per year, it would make a 225 meter station cost $900 a year, in the man and chemicals, and everything else required. In other words, a station of that kind would represent just about that amount of running expense after the plant had once been installed. There are several records of one man attending to a great many meters; but I think, perhaps, experience has shown that men vary in their ability to do that sort of work just as they do in the trimming of arc lamps, or

anything which requires care, and at the same time, rapid manipulation. I should be very glad to bring out somewhat more definite data in reference to that.

Professor. Roberts—Who does that work, the bookkeeper?

Mr. Jenks—That depends to a considerable extent on the size of the station. In a very small station, say a 1,000 light station, the superintendent does his own meter work, and can do it without any difficulty. There are two or three superintendents now, some of the oldest men in the Edison business, who, with 2,000 lamps installed, take in the bottles and replace them themselves. When the station gets a little larger, a boy is employed to do that merely mechanical work. Then the time comes when the motor man, who should be an intelligent man, does simply the weighing, and all the other mechanical parts of the business are done by a large number of people. Then, instead of making out the bills himself, he simply sends the weights to the bookkeeper or the superintendent: so it comes that we have all the way from, we might say, one-half to 3 and 4 or 5 men employed in the motor business, according to the size of the station.

Dr. Schuyler S. Wheeler—Mr. Jenks, in describing the 3-wire meter, omitted to explain the way in which the two sets of bottles took care of the 3 wires. I would like to call his attention to that. The current, in going out on the positive wire, for instance, is registered in the positive bottle. It may return through the neutral wire, and it may return through the negative. In that case it is registered in the negative bottles. After returning on the neutral wire it is registered again. The passage of the current through this wire causes it to consume another 110 volts, so that it should be charged up twice.

Mr. Jenks—I neglected to make it plain that the neutral wire acted as a compensation for the meter, as well as for the line service.

Mr. F. B. Crocker—I would like to add a word or two to what Mr. Roberts said about the general accuracy of meters, and the particular accuracy of electric meters, or inaccuracy, if people prefer to put it that way. The meter is synonymous with fraud in the popular mind. But, I think, it is more a question of human nature than anything inherently bad in the meter. The gas meter, as Mr. Roberts said, would probably, if tested in New York, be found to be in favor of the customer in at least three cases out of four; and in the case of large errors, they would almost always be in favor of the customer, for the reason that the gas meter is a gas engine; it is worked by the gas, and the gas must flow through in order to work the meter. Now the gas may flow through and not work the meter, if the meter is stuck, or the friction is great, or there is any other fact about it that is antagonistic to the proper working of the meter. Now, something the same is true of this Edison meter (that the electric current operates the meter, therefore the current must flow in order that the meter shall record). On the other hand, the current may flow without fully recording its value. For instance, if the contacts are all in the meter circuit, why the friction of the current that should pass through the meter will not pass through the meter, and it is possible that no current at all will pass through it, and yet a large amount of current be used in the house. In fact, in any meter it is almost always the case that the current is much more apt to flow, or a commodity, whatever it may be, gas, water or electricity is much more apt to flow and not record than that a record can be made without any current passing. And I think that fact is forgotten when people condemn meters; because the very nature of the apparatus necessitates that whatever is measured shall pass through in order that it may be recorded. Now, as to whether the company simply reads one thing, and charges for another, of course, has nothing to do with the meters. It is entirely outside of the theory or practice of meters; it is merely a question of pen and ink. But I think the meter is as accurate as any other practical instrument, and I think that gas is measured as accurately as cloth or milk.

Mr. Pope—Or coal.

Mr. Crocker—Or coal, or any other commodity that is furnished to the public as measured. And the fraud, if it does occur, and I suppose it does in some cases, is a case of deliberate fraud where the method and apparatus for making the measurements may be perfectly correct; and it is after the meter has done its work that the bookkeeper puts the increment on to the people, which the meter has to take the discredit for. There are so many more people who talk against meters than are in favor of them, that I think a word said now and then on the other side is no more than fair.

The Chairman—Perhaps the gas companies will at last find some cause to be grateful to electricians in the way the veracity of meters in general has been maintained to-night.

Mr. Howell—There is one point in the criticism which Mr. Jenks quoted from the past proceedings, which, I think, ought to be mentioned. That criticism was about as follows:—You are measuring only a very small proportion of the current which you are selling, that is a 975th part, and any error in the measurement is multiplied by 1,000, practically. Well, that is true, and yet it is not true. Although we measure a 1,000th part of the current, and multiply by 1,000, any error in the measurement is not multiplied. If we measure 1-1,000th part of the current, and multiply by 1,000, any error in that measuring bottle or in the resistance of the circuit in which the measuring bottle is placed, is multiplied by 1,000; but the percentage of the error is always the same, and if we have an error of 10 per cent. in the circuit in which the bottle is it means an error of 10 per cent. only in the result. No matter what kind of meter it is, whether that bottle is in the main circuit or in the shunt circuit, a 2 per cent. error would be a 2 per cent. in every case, and it would not be multiplied by 1,000 in one case, as the criticism would lead you to believe. I have watched the introduction of the Edison meter, in one place especially, and I have watched its growth from the very beginning. When the Edison meter was first put into stations the first thing a man asked was, "Is the Edison meter accurate?" And, really, there was, for some time, a diversity of opinion among the Edison people as to whether it was really an accurate meter. But the experience of the users of the meter has been so gratifying, and it has been so much to the credit of the meter, that you very rarely hear the accuracy of the Edison meter questioned to-day; in fact, among the Edison electric light people it is not questioned at all. It is known that the experience of the people using it for the last 6 years has shown beyond question that the Edison meter is accurate. The station I spoke of is the station at New Brunswick, N. J., which started out not to use any meters. They would make a contract with the consumer, and give him such light as they thought he would burn at a fixed rate. The more they used that system the more they were convinced that they were only getting about one-third as much for their current as they supposed they would get. To overcome that they introduced the meter, and the result of changing from the contract to the meter has been a very much diminished output from the station, and a very much increased revenue. They get twice as much in return for a given output of electricity as they did before. The accuracy of the meter at New Brunswick has been checked several times by the customers counting their lamp hours. I have never heard of a case there in which the customer got the best of the meter; I mean in which the meter was found to be wrong. My belief, and the universal belief in the Edison meter, is the result of experience with it.

Mr. F. R. Upton—I would add a word from my own knowledge of the very long course of experimenting that Mr. Edison went through to obtain the results that we now have. In the early days at Menlo Park, these various forms that have been shown on the screen were made and tried. I realize very fully, the difficulties in making any mechanical meter, or any meter that will not stick at starting. I think that those who have given attention to the meter can hardly have failed to anticipate that trouble, except with a chemical meter. In meters that use the heating effect, as we have been shown, the sticking of the meter is an uncertain quantity, and is invariably against the company; those meters will never be used. If the error were in favor of the company, I have no doubt they would be largely used, but they are invariably against the company. The Edison meter is formed with the zinc plates instead of copper plates, which were first proposed. That represents a large amount of work at Menlo Park, and again at the Edison machine works, in Goerck street; and since then, Mr. Jenks has given an immense amount of time to it, so that it has to-day, been built up into an instrument of most thorough accuracy.

Mr. Edgar (of the Edison station, Boston)—We are using about 800 meters, and I have the utmost confidence in them. I have tested a great many, and I have had our customers test them for us. I have known of numbers of cases where they have proved within one per cent., and I never have known of a case where we had to retreat from the position that the meter was correct. We have a large number of meters, and are able to determine exactly the horse-power hours per month of each meter; thus being able to make a contract price in the next case, which would be more satisfactory than if we had not made those tests.

One gentleman asked a question to-night, as to the cost of meter service. We have 800 meters. In that department there are five men; three of them are, practically, boys who go around town collecting bottles. We extend over a territory nearly three miles from one extreme to the other. The fourth man does the weighing, and the fifth man makes out the bills and sends them up to the bookkeeper, ready to be mailed; so that we really do more in the meter department than is usually done in a department of that kind. It costs, perhaps, $2,500 a year to take care of the work of our 800 meters. A great many, as I have said, are on motors where we are experimenting, making changes once a week, so as to get at a fair average for different classes of work.

Mr. Howell—I suppose everyone here knows that there has been a great deal of inventive energy wasted on meters. The records of the patent office show an enormous number of mechanical meters, and I think the Edison company have had about as many presented to them as anybody has. The great point in favor of the Edison meter, as compared with any other, is its cheapness. If we want to equip a station with 800 meters, like Mr. Edgar's station, it makes a very great difference whether we have to pay for a complicated mechanical contrivance, which is necessarily expensive; or whether we have to buy a box with a couple of pieces of german silver and two bottles in it. The element of

first cost is a very significant factor in favor of the Edison meter. You can pay for your meters almost as much as you would for the station itself. A successful meter must have two qualities: it must be good, and it must be cheap; and I think, the Edison meter has those two qualities very preeminently.

Professor Roberts—As to mechanical meters, it is an open question whether we cannot some day arrive at a mechanical meter which will be satisfactory. So far as cheapness is concerned, certainly, a Waterbury watch is as cheap as these two bottles and two pieces of german silver, yet there is a great deal of mechanism in it. I wish to bring up one point showing how the customer, if he finds any expense kicking up against him, will want to economize. A station I know of has a 12″ by 36″ Corliss engine. The lamp renewals were paid for by the company, and the lighting done by contract price, and everything was running beautiful; the engine was supposed to be developing about 65 h. p. (the indicator card showed about 100 h. p.) from 6 o'clock in the evening to about 10; then it dropped down somewhat. The charge for a new lamp was about 75 cents; the customer expected it was to burn about 1,000 hours. As soon as he got a bill the indicator card showed that the engine was developing 75 h. p. instead of 100. Therefore, they saved over 25 per cent. of power just as soon as the customer felt that the lamp breakage alone was being charged against him. I do not doubt that the gentlemen who have employed both the contracting and the meter system can show even more remarkable figures than these.

Mr. Brown—Into the construction of this meter there entered one material on which there has been considerable discussion during the last year, namely, german silver. It, perhaps, will not be out of place to inquire whether they have any special standard of excellence for german silver at the Edison laboratory.

Mr. Jenks—As I said in general, in the description, the best german silver that can be obtained is used, that is to say, a quality equal to that employed in making bridges is used in the metal shunts. Of course, the standard, so far as the construction of each individual meter is concerned, comes in the resistance, and that resistance has to be determined to within a very minute fraction of an ohm in the placing of the strip in the box before it can be standardized.

Mr. Evirt—I happen to know that the german silver used in the Edison meter is 18 per cent. german silver, and it gives a little better temperature co-efficient than that quoted in books, I believe. It is said that some electric light men are very prone to mix what has been done with what is about to be done. I want to say that Mr. Jenks has been extremely conscientious in describing the Edison meter as it has been, and not as it is about to be. No changes of a radical nature have been made in it since it was first introduced. I may say that there has been practically concluded now a series of experiments on the meter, and the company are getting ready to offer a new meter which will be a great deal better in many respects, *i. e.*, in the cost of the meter, in the decreased cost of operating, and in the much less strain on the meter man's back. It appears to us that, given a spool with a piece of german silver, the Edison meter depends on the laws of electrolysis and chemical balance; and the chemical balance is probably the best and most reliable and most sensitive instrument known. So it appears to us that we do not need any large quantity of zinc to weigh or to carry about, and we propose to reduce it to one-half, in some instances to one-fourth, and in some instances to one-eighth, so that the box will be about half the size it is at present. The bottle will be half its present size. In place of two bottles there will be one bottle. We will call on the balance for the accuracy we can get out of it, and call upon the meter man for a little more pains.

The Chairman—Are there any other speakers? Although the hour has arrived and gone by when we usually adjourn, there is an opportunity for further remarks. The secretary has some announcement to make, I think.

The Secretary—I have to say that in view of the approaching International Exhibition at Paris, several engineering societies here have received invitations to participate in meetings held by various similar societies abroad, and the Institute has received two letters, one from the Institution of Civil Engineers, and one from the Society of Arts, in London. I wish to read these, and bring to your attention the arrangements which are being made by the Society of Mechanical Engineers for an excursion to Europe.

The secretary then read the communications referred to.

THE INSTITUTION OF CIVIL ENGINEERS,
Established 1818.—Incorporated by Royal Charter, 1828.
25 Great George St., Westminster, S. W.,
November 23d, 1888.

To the Secretary of the
American Institute of Electrical Engineers,
New York City, U. S.

Sir—It is reported that many engineers from the United States will probably visit Europe during the International Exhibition which is to be held in Paris in 1889.

In view of this, the council of the Institution of Civil Engineers, at the first meeting of the present session, directed an inquiry to be addressed to you to ask: 1st. Whether this report is correct, and, if so, whether your Institute can give any idea of the number of your members likely to come. 2d. Whether they will travel by way of England; and 3d. What may be expected to be the approximate date of their arrival, and the duration of their stay in this country.

The object of this inquiry is to enable the council to consider the possibility of making such arrangements as may best tend to further the objects which the visitors have in view, and to render their visit as useful and agreeable as possible

The council need hardly assure you of its good will toward its professional brethren in the United States, and of its desire to embrace this opportunity of manifesting its friendly feeling to the utmost of its power.

Of course, in any case, the facilities afforded by this Institution are always at the disposal of your members.

We are, yours faithfully,
GEORGE B. BRUCE, *President*,
WILLIAM POLE, *Hon. Secretary*,
JAMES FORREST, *Secretary*.

SOCIETY OF ARTS,
John Street, Adelphi,
London, W. C.,
December 8th, 1888.

Sir—The council of this society have been given to understand that a visit of American engineers to this country during the spring or summer of next year is in contemplation.

The council will be very glad if the Society of Arts can in any way facilitate the visit of your members to England, or render their stay here more pleasant. They will be glad to place the rooms of the society at their disposal; and if their visit should coincide with the society's annual conversazione in June, they will be very pleased to see as guests on that occasion such of your members as may be able to attend.

We have the honor to be, sir, your obedient servants,
ABERCORN, *Chairman of Council*,
H. TRUEMAN WOOD, *Secretary*.

The Secretary of the
American Institute of Electrical Engineers.

The secretary read also a circular issued by the American Society of Mechanical Engineers, announcing a projected excursion of engineering societies to Europe during the French Exhibition, including the following information :—

DATES.

Minimum absence, five weeks. From last week in May to first week in July.

COST.

Round trip passage by steamer, $110, going altogether in a body and returning individually at any time during the year, as may be convenient. Cost per day per person on shore from $4.00 upward, according to personal ideas.

The trip will begin soon after the adjournment of the Erie City Convention of the Mechanical Engineers.

The Inman Line will reserve for our party either the steamer City of Richmond or the City of Chester, giving us the entire first cabin for our exclusive use, provided we will guarantee 150 persons, including the ladies, at the above rates. By having our own steamer, the sailing day may be fixed to suit our convenience, to say nothing of the social advantage of being by ourselves and in control of the ship.

The secretary said further—About a week after the circulars of the Mechanical Engineers were issued by secretary Hutton, I was informed that they had already received affirmative responses from 75 members; so it appears probable that the arrangement for a special steamer can be carried out. I am in negotiation with Mr. Hutton now in regard to the preparation of our own circulars. I bring it up to-night in order to give you this information in advance, to guide you in arranging for your vacation, and to induce you to save your money meanwhile.

The next meeting of the Institute for the discussion of papers will be held on Tuesday, January 8th. The subject of the paper will be "Lightning Arresters, and the Photographic Study of Self-Induction," with numerous illustrations and experiments, by E. G. Acheson, member, electrician of the Standard Underground Cable Co.

RULES AND REGULATIONS FOR OVERHEAD CONDUCTORS FOR ELECTRIC LIGHT AND POWER.

Adopted November 13, 1888, and Promulgated by the Board of Electrical Control of New York.

I. No two lines of poles bearing conductors of a like class shall be erected on any street or avenue.

II. No two lines of poles shall be erected on the same side of any street or avenue.

III. Poles shall be set in the sidewalk twelve inches from the outside of the curb, and no pole shall be placed within ten feet of any lamp post or other pole, except at street corners where necessary in order to support wires running on the cross street.

IV. All poles now standing, or to be hereafter erected, shall be branded or stamped with the initials of the company owning them, at a point not less than five nor more than seven feet from the street surface; and when a pole is occupied by wires belonging to more than one company, each group of cross-arms, or where necessary the support of a single wire of different ownership, must be distinguished by some characteristic paint mark or fastening.

V. Electric light lamp-posts shall be in accordance with the plan adopted by the Board.

VI. All poles erected for the purpose of carrying lines of more than two electric light or power wires shall be at least forty-five feet high, uniform in size, straight and painted from top to bottom a very dark color from the sidewalk to a point eight feet high, and a dark green color above that.

VII. All poles for carrying not more than two electric light wires shall be twenty-five feet high, straight, uniform in size, and painted from top to bottom—a very dark color from the sidewalk to a point eight feet high, and a dark green color above that.

VIII. Cross-arms shall be uniform in length, strengthened by braces, and painted the same color as the poles; the cross-arms of each company being distinguished by some characteristic mark.

IX. Each line of poles must be run on one side of the street only, except when absolutely necessary to change to the other side; but this may only be done by the permission of the Board or of its engineer or expert.

X. Electric light conductors must not be placed upon fixtures erected or maintained for supporting wires of the other class, namely, those for signaling, except by permission of the Board.

XI. Poles shall be uniformly spaced, and about sixty to the mile. This requires on the short city blocks of two hundred and sixty feet, alternately three and two poles to the block.

XII. All conductors shall be secured to insulating fastenings, and covered with an insulation which is water-proof on the outside and not easily worn by abrasion. Whenever the insulation becomes impaired it must be renewed immediately.

XIII. No wire shall be stretched within four inches of any pole, building or other object, without being attached to it and insulated therefrom.

XIV. Every wire must be distinguished by a number plainly marked on each cross-arm under the insulator.

XV. No unused loops from electric light circuits shall be allowed to remain after lamps are taken away, except in cases where it is positively known that the lamp will be required again within three months, and where there is no underground conduit for that class of circuits.

XVI. All arc lamps must be so placed as to leave a space underneath of nine (9) feet clear between lamp and sidewalk.

XVII. All wires must be stretched tightly and fastened to glass or porcelain insulators, approved by the expert, with a strap of the same kind of wire.

XVIII. All connections with lines of electric light conductors shall be made at right angles to the same; and connections to buildings shall be run straight across to the building, and then down the front of the building.

XIX. All joints must be as well insulated as the conductors, and the insulation of joints must be maintained.

XX. Every line entering a building shall be controlled by a cut-off placed near the entrance, in sight, and easily accessible.

XXI. No wires shall hang within twenty feet of the pavement at the lowest point of sag between supports.

XXII. In the construction of lines the insulation to be used must be approved by the expert of the Board in writing, and the insulation resistance must be maintained in accordance with a standard to be not less than $\frac{1}{10}$ megohm per mile per hundred volts. And under no circumstances shall underwriters' wire be used.

XXIII. All circuits must be tested every hour, and when a ground comes on, effort must be made to remove it at once. Failing in this, the current must be discontinued until the insulation is restored.

XXIV. The insulation must be preserved throughout the entire circuit, and if any portion of a lamp or fixture is a part of the circuit and can be touched, it must be insulated.

XXV. All conductors shall have a resistance uniformly distributed of not more than 30 ohms per mile per ampere, and proportionately less for heavier currents.

XXVI. All existing regulations of the local authorities in regard to the placing of poles and stringing of wires are to continue in force, except when in conflict with these rules; and the rules and regulations of the New York Board of Fire Underwriters must be strictly observed.

XXVII. The violation of any of the rules and regulations of the Board shall operate *ipso facto* as a revocation of the permit held by the company or person guilty of such violation.

XXVIII. Whenever hereafter any company shall be permitted by this Board, or its successors, to erect posts or poles, or other fixtures bearing lamps or other devices, for the purpose of lighting by electricity the streets, avenues, highways, parks or public places of the city, the said permission shall be granted only subject to the following provisions, and the same is hereby expressly made a condition of said permits. At any time when, by action of the city authorities, the contract for lighting any such street or other public place shall be given to another company, the company erecting said lamp posts shall, on tender of the first cost thereof, yield possession and ownership of the same to the said other company obtaining the new contract, except in cases where the company owning the lamp posts prefers to remove them.

XXIX. All broken and "dead" wires, and all wires, poles and fixtures not actually in use—subject to rule XV—must be removed from the streets, avenues and highways of the city. When an old pole is taken down it must be removed from the streets the same day. New poles must not be brought upon any street more than two days in advance of their erection. Any pole that shall lie on any street more than two days shall be removed by the Bureau of Incumbrances of the Department of Public Works, at the expense of the party owning it.

XXX. From and after the first of January, 1889, no company shall do business of arc electric lighting in the City of New York without a certificate of the Board, granted on the recommendation and after inspection by the expert of the Board, to the effect that its lines comply with all the rules and regulations of the Board, and that its plant is in proper condition for the doing of its business. The force of the certificate to continue until changes are made, of which the Board must be notified and approve, or so long as the plant and conductors remain in the same condition as when inspected.

XXXI. Every lineman must wear a badge in a conspicuous place, giving his number and the name of the company by whom he is employed.

XXXII. All permits of the Board for overhead wires and fixtures are granted only pending the providing of underground accommodations in the neighborhood of the street or avenue for which the permit is granted.

XXXIII. Any member or officer of the Board, and every inspector employed by it, as well as every member of the police force of the city, shall be entitled to examine permits under which work of any kind is being done.

XXXIV. No permit shall be granted for the erection of any overhead structure nor for the renewing of any lines already existing in any street, avenue or highway in which underground accommodations for the service have been provided, or are being provided.

XXXV. Every line, pole, fixture, etc, must be kept in thorough order, repair, and conformity with these rules and specifications, upon penalty of forfeiture of all permits granted to the owner by this Board.

But the general permit under which these repairs are to be made does not cover the erection in any street, avenue or highway of any new poles or other similar fixtures, and has absolutely no reference whatever to lines which have been ordered underground by the Board, and which the Mayor has been requested to remove.

In the case of such lines, where notice has been given that underground accommodations have been provided, and the ninety days of notice required by law have elapsed, and the Mayor has been requested to remove the same, companies owning or operating said lines are not authorized to make any repairs or connections or to go upon the poles bearing such lines *for any purpose whatever*, except to remove the said lines of electrical conductors in conformity with the directions of the Board.

Any deviation from this rule requires a resolution passed at a regular meeting of the Board, attested by the secretary.

XXXVI. Every company or person erecting poles, wires or fixtures must make and leave, at least once each week, at the office of the Board, such records of the fixtures, etc., which they are erecting, and of all of the same that they have in use, as are required by the engineer and the electrical expert of the Board, and in such form as shall be prescribed by them.

XXXVII. The companies or persons owning or controlling poles in any street or avenue, erected under permits of this Board or the Board of Electrical Subways, shall allow the same to be used by other companies or persons operating conductors for similar electrical service when authorized so to do by the Board, on tender of proper compensation to be determined by agreement between the parties interested. In default of such an agreement the amount of such compensation shall be determined by the Board. This rule imports a contract on the part of each company or person owning or controlling the poles on any street or avenue, not only with the Board but also with each company or person who shall under its terms be qualified to demand the privileges it confers, to permit this joint use of poles.

And in accepting any permit the applicant thereby binds himself to this agreement.

POINTERS.

.... In the Central Savings Bank, in London, it has been found after two years' experience of electric lighting, that the average amount of absences from illness has been diminished by about two days a year for each person on the staff. This is equivalent to a gain to the service of the time of about eight clerks in that department alone. Taking the cost at the "overtime" rate only, this would mean a saving in salaries of about £640 a year.—*W. H. Preece.*

.... Few will be prepared to deny that pure electrical science has received an enormous impulse, and has been advanced by the commercial application of electricity to purposes of lighting.—*Sir Frederick Bramwell.*

.... It will not merely be for the inauguration of the quick transmission of our bodies by steam, or the quick transmission of our thoughts by telegraph, but for the economical transmission of power by electricity that the Victorian age will be remembered. —*Professor Ayrton.*

.... When that evil day arrives that our supply of natural fuel ceases, we may look to electricity to bring to our aid the waste energies of nature—the heat of the sun, the tidal wave of the ocean, the flowing river, the roaring falls, and the raging storm. —*W. H. Preece.*

MINIMIZING THE BANEFUL EFFECTS OF THE EXTRA CURRENT.

The injurious effects of the extra current of rupture in a circuit of considerable self-induction are of two kinds. The sparks which burst at the point of rupture (primary circuit of Rhumkorff's coil, brushes of dynamos, telegraphic apparatus, &c.), oxydize the contacts, increase the resistance, and reduce the useful effect of the current. From a physiological point of view, the danger of the extra current is still more serious, and may become deadly.

Various means have been proposed to lessen these effects: (1) a condenser employed in the manner of Fizeau (Rhumkorff's coil); (2) condenser in derivation between the extremities of the electro-magnet (relays and telegraphic apparatus); (3) rheostat in derivation on a dynamo (D'Arsonval, *Comptes Rendus*, January and March, 1885); (5) telegraphic lightning rod in derivation (Raynaud, *Comptes Rendus*, March, 1885), &c.

I purpose to show how the conditions of efficiency of these means may be submitted to calculation and expressed in figures. To this end we shall admit that for the suppression of these injurious effects the difference of potential at the extremities of the electro-magnet should not at any moment exceed a maximum, E, the value of which has to be fixed (100 volts, 200 or 500 volts, as the case may be).

1. *Rheostat in derivation on the electro-magnet.*—Let R be the resistance of the electro-magnet, I the normal intensity of the current traversing it, ρ the resistance of the rheostat, the self-induction of which may be overlooked. On the rupture of the exterior circuit the electro-magnet and its shunt form a closed circuit, in which the current sinks gradually from I to zero. The maximum difference, V, of potential at the extremities of the shunt, and consequently at those of the electro-magnet, cannot exceed $\rho\ I$. It results that the efficiency of the shunt will be secured if we take ρ less than $\frac{E}{I}$.

Example.—Morse electro-magnet ($R = 500^{\omega}$, $I = 1.015\ a$ = normal working current). If we wish that V should not exceed $E = 150^{v}$, we only need give the shunt a resistance ρ less than $10{,}000^{\omega}$.

If we take account of the very slight self-induction of the shunt, the result is not sensibly affected. The calculation would be too long to be developed here.

Voltameters in derivation.—We take voltameters of such a number that their maximum electromotive force, e, may slightly exceed the normal difference of potential, $R\ I$, at the extremities of the electro-magnet. Let R be their resistance.

On repeating the above reasoning, we find that the maximum difference of potential, V, at the extremities of the electro-magnet during the rupture cannot exceed $\rho\ I + e$, or approximately $(\rho + R)\ I$. If the resistance, ρ, of the voltameters is small, V will scarcely exceed the difference of potential, $R\ I$, of the normal condition.

By reason of their considerable capacity of voltaic polarization, the use of voltameters is suitable only in case of currents essentially variable (telegraphic transmissions, alternating dynamos, &c.).

3. *Condenser in derivation on the electro-magnet.*—Let R and L be the resistance and the self-induction of the electro-magnet, I the normal current, C the capacity of the condenser. On the rupture of the exterior circuit, the electro-magnet and the condenser form a closed circuit, in which the current, i, declines gradually from I to zero. This current, i, causes the charge $C\ v$, of the condenser to decrease, and consequently the difference, v, of the potential at the extremities. When the discharge is complete, if the intensity, i, is reduced to zero, the extra current comes to an end without v having exceeded the normal difference of potential, $R\ I$, the condition of efficiency is, of course, fulfilled.

This case occurs when C exceeds the value of $\frac{L}{4\ R^2}$ as a calculation in full would show.

But it may happen that when the charge of the condenser becomes null, the current has still an intensity, $i < I$. The charge, $C\ v$, continues then to decrease. v equally changes its direction, and reaches a maximum, when the current, i, becomes null. Then the condenser discharges itself anew, and thus in succession. This is the phenomenon well known as the oscillating discharge. The point is to keep V below the fixed maximum, E.

At the moment when the condenser is entirely discharged, the current having the intensity, i, the energy still to be expended is $\frac{1}{2} L\ i^2, < L\ I^2$.

Then, since the intensity, i, has fallen to zero, the energy still available is $\frac{1}{2} C\ V^2 < \frac{1}{2} L\ i^2$. Then, in order that V may be smaller than E, we must have

$$\tfrac{1}{2} L\ I^2 < \tfrac{1}{2} C\ E^2 \text{ or } C > \frac{L\ I^2}{E^2}.$$

This is a *sufficient* condition of efficiency; the *necessary* condition is obtained by a calculation too complicated for practice. We shall therefore adopt as the lower limit of the capacity C, the value $\frac{L\ I^2}{E^2}$ or the value $\frac{L}{4\ R^2}$ if this is lower than the former.

Example.—Electro-magnet Morse ($L = 10$, $i = 0.015\ a$), if we fix $E = 150$ volt we must take C greater than 10^{-7} farad or $\frac{1}{10}$ microfarad.

4. *Case of an intentional rupture of the circuit.*—We may break a circuit by introducing resistances increasing progressively up to infinity. The duration of such a rupture must not be less than $\frac{L\ I}{E}$ if we wish the electromotive force of self-induction not to exceed the fixed maximum E. The law according to which it is advantageous to introduce the progressive resistances is easily calculated.

The other means which have been proposed or which might be studied with a view to reduce the bad effects of the extra current may be calculated in an analogous manner.—M. VASCHY, in *Comptes Rendus.*

A NEW METHOD OF PROPELLING BOATS.

A successful trial trip was made this month from Brooklyn of Mr. John A Secor's yacht, "Eureka." The boat is propelled by the explosion of atomized petroleum which is ignited at intervals by an electric spark, the action being somewhat similar to that of a gas engine. The method, however, of applying this power is decidedly novel, the cylinder extending down into the water at the bow and stern, and large pistons pushing against the water at each explosion, thus propelling the boat forward. A larger boat is being constructed, and it is stated will be launched the coming spring.

A CONDITION OR A THING?

A telegram from Harrisburg, Pa., suggests the novel question whether electricity is a "condition or a thing." It says: Although philosphers have never been able to determine whether electricity is a condition or a thing, a case will be tried by the courts of Dauphin county next month in the hope of throwing light on a very ancient dispute. Under the act of 1885 manufacturing companies in Pennsylvania, with few exceptions, are exempt from taxation. The state authorities have refused to recognize electric light companies as manufacturers, and several of these corporations have appealed from the settlement of the tax which the commonwealth has imposed upon them. The novel point to be decided is whether or not electricity is manufactured.—*Light, Heat and Power.*

BOSTON STREET LIGHTING CONTRACTS ATTACKED BY THE CITIZENS' ASSOCIATION.

The executive committee of the Citizens' Association of Boston, Mass., presented a communication to the city council, under date of November 19th, drawing attention to the existing contracts between the city and the several electric light companies under which the city is paying at the rate of 65 cents each per night for arc lights. This price, the committee claim, is excessive, and in substantiation thereof submit figures which they have received from the authorities of several large cities. In all of these cities, it is claimed that the standard of measurement of candle-power, and the number of hours which the lights are kept burning, and all other conditions, are similar to those prevailing in Boston. The figures given by the committee are as below :—

Cities.	Date.	Lights.	Cents.
Albany, N. Y.	Not given.	481, at	.50
Baltimore, Md.	"	519, at	.50
Brooklyn	July 2, 1888.	1014, at	.50
Buffalo	Nov. 16, 1888.	996, at	.45
Fall River, Mass.	Not given.	260, at	.55
Fayette, Ind.	"	207, at about	.26
New Orleans	June 13, 1888.	822, at	.34
New York	June 12, 1888.	1435, at	17½ to 35, Average 34½
Philadelphia	June 13, 1888.	756, at	47½ to 55, Average 50
Providence, R. I.	Not given.	295, at	.50
Scranton, Pa	"	212, at	.20
		100, at	.35
Syracuse, N. Y	"	280, at	.39
Troy, N. Y.	"	392, at	.48½
Utica, N. Y.	"	375, at about	.30

The existing contracts were made for three years, and terminate on January 7th, 1890; but the committee claim that they are clearly illegal on the grounds that the city charter provides that "no expenditures shall be made nor liability incurred beyond the appropriation duly made therefor," and also because "it is doubtful whether a city council has a legal right or power to bind its successors for any term of years indefinitely."

It was brought out in the course of the discussion upon the petition, that at the time the contracts were made, several other cities, notably New York and Baltimore, were paying considerably

more for this service than 65 cents per light per night; and it may be noted in connection with the figures given by the Citizens' committee as the cost of lighting in other cities, that these figures differ somewhat from those furnished by others.

THE WESTERN UNION TELEGRAPH COMPANY.

REPORT FOR THE QUARTER ENDING DECEMBER 31, 1888.

Executive Office,
Western Union Telegraph Co.

New York, December 12, 1888.

The following statement exhibits the condition of the company at the close of the quarter ended September 30, 1888 :—

Surplus, July 1, 1888, as per last Quarterly Report.		$7,498,548.94
Net revenues, quarter ended September 30, 1888...		$1,707,378.94
		$9,205,927.88
From which deducting for—		
Dividend of 1¼ per cent. paid Oct 15...	$1,077,376.89	
Interest on bonded debt	184,802.08	
Sinking funds........................	19,991.00	
	1,282,169.97	
Left a surplus October 1, 1888, of.................		$7,923,757.91
The net revenues of the quarter ending December 31st, instant, based upon nearly completed returns for October, partial returns for November, and estimating the business for December, will be about......		$1,650,000.00
Add surplus, October 1, as above.......		7,923,757.91
		$9,573,757.91
From which appropriating for—		
Interest on bonds...	$184,802.08	
Sinking funds.........................	20,000.00	$204,802.08
Leaves a balance of		$9,368,955.83
It requires for a dividend of 1¼ per cent. on the capital stock		1,077,376.89
Deducting which, leaves a surplus, after paying dividend, of.....................		$8,291,578.94

The gross receipts for the quarter ended September 30, were $5,305,703.25, being an increase over the corresponding quarter of last year of $458,157.33. The expenses were $3,598,324.41, showing an increase over the same quarter of last year of $57,689.70.

In view of the preceding statements, the committee recommend the adoption by the board of the following :—

Resolved, That a dividend of one and one-quarter per cent. on the capital stock of this company be hereby declared payable on and after the 15th day of January next, to stockholders of record at the close of the transfer books on the 20th day of December, instant.

Resolved, That for the purpose of the dividend hereby declared, the stock books of the company be closed at three o'clock on the afternoon of the 20th day of December, instant, and be reopened on the morning of the 2d of January next.

The resolutions were adopted by the board of directors.

Respectfully submitted,

NORVIN GREEN, *President.*

A CABLE TO AUSTRALIA via VANCOUVER.

The Earl of Winchelsea and Nottingham presided at Cannon Street Hotel, London, early in December over a very influential meeting of merchants and other gentlemen interested in the Canadian and Australian Colonies. The meeting was convened chiefly in support of the scheme for laying duplicate lines of cable to Australia *via* Vancouver. Lord Winchelsea said the advantages of the Pacific route were numerous and obvious. It was especially safe in times of war, and thousands of miles of it would be actually in British territory. When they commenced business the maximum rate would be 4s, compared with from 9s to 10s charged by the existing companies. They wished for no subsidies. All they asked of the various Colonial Governments was that they should use the new cables to the extent of £75,000 per annum. The cable, however, was only part of their scheme, which included two lines of steamers—every vessel fitted as an armed cruiser. They must remember that in case of war troops could be concentrated at Vancouver and landed thence in India or Australia with ease. Resolutions in support of the scheme were carried, the speakers including Sir Donald Smith and several prominent Australian colonists.—*The Engineer and Iron Trade's Advertiser.*

THE TELEPHONE.

The Paris-Brussels telephone line, the prime cost of which was covered by the first year's receipts, now yields some £4,800 per annum. It will be remembered that the Van Rysselberghe system is used on this line; and since the line is of phospor and silicium bronze it gives satisfaction. It is also claimed that much of the success attained is due to the Dejongh telephones which are employed.

ELECTRIC LIGHT AND POWER.

THE NEW YORK UP-TOWN STATIONS of the Edison Illuminating Co.—Service from the 39th street station was begun Thursday evening, December 27th, current being supplied to the lamps already placed in the Union League Club House. The two stations planned for the up-town service in 22d and 39th streets are very nearly completed, and ground has been bought for a third station in 53d street. The two very substantial and well appointed station buildings already erected will have a capacity of 35,000 to 40,000 lamps each when fully equipped. The electric light will, therefore, soon be available for residences throughout a large portion of the city, including the finest residence district.

PITTSBURGH, PENNA.—The contract for the city lighting has been awarded to the East End Electric Light Co. at $110,592 per annum. The plant will comprise 400 arc lights of the Waterhouse system, and 4,287 incandescent lights of the Westinghouse system. The bid of the Fort Wayne Jenney Company was $119,035.50. The East End Electric Light Co. have filed approved bonds for performance of contract and protection to the city from infringement suits in the sums of $25,000 and $50,000 respectively.

THE HEISLER ELECTRIC LIGHT CO., of St. Louis, has received an order for a central station plant for Michigan City, Indiana, which is expected to be completed and in operation before the first of January.

TESLA MOTORS.—The experiments conducted by the Westinghouse Electric Co. during the last three months with the Tesla motors are reported to be most satisfactory. A form has been perfected that will operate on the existing alternating circuits for the running of fans and other light machinery, and also the large motors for street car purposes and power purposes generally have been brought to a high degree of perfection and efficiency.

THE HEISLER COMPANY, of St. Louis, have already shipped the dynamos for the plant recently ordered by the Puebla Gas Light Co., and the work of construction is now going forward at Puebla. This plant will include street lighting as well as commercial and private lighting. Some 15 miles of line circuit will be required for the work laid out by the Puebla company. Armington and Sims and Ball engines will be used.

THE JULIEN ELECTRIC CO. report sales of 2,130 accumulators for the month of November, and 750 for the first 12 days of December.

Foreign.

Australia.—The Sandhurst-Eaglehawk Tramway Co., Melbourne, has ordered storage battery cars for its road, designed by Mr. Reckenzaun. The speed is to be five miles an hour up gradients of one in 20, and on the level eight miles an hour. The cars are provided with two 8 h. p. motors, worked from a battery of 72 storage cells.

England (London)—At a meeting of the court of common council, held at the Guildhall, the chairman of the city commission of sewers stated that they had taken the advice of Mr. W. H. Preece, and of Col. Haywood, their engineer, and that an agreement had virtually been come to regarding the manner in which tenders for the electric lighting of the city should be invited. It was stated that every important electric lighting company would be asked to tender.—The action of the Metropolitan Electric Light Co. in giving the order for their first central station to the Westinghouse company, has caused some dissatisfaction on the part of English contractors; but this feeling is likely to subside now that tenders for a second station have been invited on the understanding that an English firm will receive the contract. The Metropolitan company will thus be in a position to test by actual practical work whether the American or some English system of lighting is the best, and future orders will be given out according to the results of this test. The tenders now invited are for the whole of the generating plant (steam and electrical) required for the supply of 10,000 lamps, and for the transformers, but not for the mains.—*Industries.*

France.—THE PARIS MUNICIPAL ELECTRIC LIGHTING STATIONS.—The 25th and 26th of October, were the dates fixed for opening the tenders for the steam and electrical plant required in this installation. Eight firms have tendered for the electrical plant, viz., La Société Continentale Edison; La Société Lyonnaise; La Société Alsacienne; La Société d' Eclairage Electrique Jablochkoff; M. Patin, the representative of Mr. Ferranti; M. Victor Popp, the representative of the Thomson-Houston company, and M. Cuenod-Sautter. After inspecting the tenders of these parties, a sub-committee, under the presidency of M. Mascart, was formed, and instructed to examine the rival schemes in detail, and recommend one for adoption. The final decision is expected in December.

France.—CENTRAL STATION LIGHTING.—The Continental Edison Company are establishing a small central station in the gar-

dens of the Palais Royal, from whence current will be supplied to the Théâtre Français, and to the large shops immediate in the vicinity. The capacity of the station will be about 1,500 lamps. Several of the shop-keepers in the neighboring streets have applied to the company for current; but as they could only be reached by underground conduits, special permission from the municipal authorities is required, and this question was brought before the Council at their last meeting, but without effect. At the same meeting it transpired that none of the tenders sent in by electric light firms for the installation at the "Halles" was in complete conformity with the regulations laid down by the commission. No tender has consequently been accepted, and there are not wanting critics who affirm that the delay in getting to work is simply due to the fact that many of these regulations as contained in the *cahier des charges* are impracticable, and must be modified before contractors can accept them. This means more commissions and reports, and if things go on at the present rate there is no chance of the Halles installation being ready by the time the Exhibition opens.

Germany.—The central station in the Markgrafenstrasse, Berlin, is now being enlarged by the addition of four dynamos, each having an output of 100 kilo-watts. These machines have been made by Messrs. Siemens on their new plan, with internal field magnets, the armatures being of very large diameter, and coupled direct to the steam engine. The engines are of the vertical compound tandem type, and have no fly wheel except the armature. To save room, the crank shaft has been placed low down, and a pit has been provided in the foundation, within which the armature revolves. Owing to the large size of these machines, it was not considered advisable to finish them completely in the factory, and the armatures have been wound *in situ*. Similar machines are already at work at the railway station at Frankfort-on-the-Main. In addition to the two new central stations projected for Berlin, there will be erected a third station, bringing up the total capacity of electric lighting plant to 18,000 h.p., capable of supplying 200,000 lamps, which is about one-quarter of the total number of gas burners fixed in Berlin. The present capacity of the two existing stations is 3,800 h.p. In the future it is proposed to use for central station lighting steam engines of 1,000 h.p., instead of the present unit of 300 h.p., in order to reduce the proportional cost of attendance. All the manufacturers of glow lamps are busy, and are hardly able to fill the orders they have received for the present season. In many cases works are being enlarged, and the company making the Seel lamp are not only extending their manufactory to three times its present size, but are also projecting the erection of branch factories in Germany and abroad. A demand has lately arisen for lamps of high voltage, and several manufacturers have already made experimental lamps for 150 and 200 volts. In no case was the lamp found good enough for practical use. The general defect of all these lamps is that the thin filament is either broken from purely mechanical causes, or when heated by the current, bends and touches the glass, with the result of causing the latter to crack.—*Industries.*

ELECTRICAL SOCIETIES.

THE BUFFALO ELECTRICAL SOCIETY.—The Buffalo *Sunday Journal*, of December 16th, contains portraits of Messrs. Frank Kitton, Astley C. Terry, Geo. H. Usher and William Finn, together with a biographical sketch of each. The Buffalo society is one of the oldest of its class, having been organized September 11th, 1883, by several prominent telegraph operators. They have kept abreast of the development of electrical industries by mutual inquiry and discussion, and their meetings have proven of interest to electricians generally.

THE MISSOURI ELECTRICAL SOCIETY have adopted the following plan for the mutual instruction of members. A query box is provided into which can be deposited any question upon which a member desires information. By this means any embarrassment a member might feel in asking a question openly is obviated. Should the answers given not be sufficiently clear the matter can be followed by further inquiry. This plan is worthy of commendation by other similar societies for the benefit of the younger and less experienced members.

PERSONAL MENTION.

MR. A. NOLAN-MARTIN, M.A., F.S.Sc., formerly of London, Eng., is associated with Dr. Paget of the Macraeon Storage Battery Co., 7 Wall St., New York, as consulting electrician and analytical chemist.

MR. R. H. SOULE, formerly superintendent of motive power and general manager of the N. Y., L. E. & W. R. R., has been appointed general agent of the Union Switch and Signal Co., and is, among other duties, to have charge of the sale and introduction of the Westinghouse buffer referred to in our manufacturing and trade notes.

MANUFACTURING AND TRADE NOTES.

THE COMPOSITE CELL CO., D. C. Hood, general manager, have opened an office at 35 Broadway. They manufacture a composition cell for batteries, which they claim is acid proof, and of entirely new and indestructible material.

THE ELECTRO-DYNAMIC CO., of Philadelphia, Penn., has received the contract for lighting the Brooklyn Navy Yard, on their bid of $3,100.

THE ENO STEAM GENERATOR CO., 102 East 12th St., New York, have recently placed on the market a new steam generating system that is highly spoken of by mechanical engineers as well as by their patrons. The generator proper, consists of a series of pipe flues, each flue being composed of an inner and outer tube, the water being between the tubes. No coils or return pipes are used. By this arrangement a sheet of water 30 ft. square is exposed on both sides to the fire, thereby securing a very rapid generation of steam, and causing an excellent circulation. The action of this system is demonstrated practically to visitors by models with glass connections in operation at the company's offices.

MESSRS. WILLIS & HUNTER have opened an office at 115 Broadway, for the sale of the Eddy electric motors.

MR. FREMONT WILSON has opened an office at 35 William st., as an electrical contracting engineer.

JUDGE W. H. ARMSTRONG, of the Pacific Electric Storage Co., the licensees of the Electrical Accumulator Co. for the Pacific Coast, was in the city recently.

THE ECONOMIC GAS ENGINE CO. exhibited a new type of gas engine at the American Institute Fair, which has just closed.

THE STANDARD ELECTRICAL WORKS, of Cincinnati, Ohio, have just placed on the market a new gravity drop annunciator possessing several improvements over the old style. The drops are mounted upon iron backs, and the shields are set down close to the magnets, thus securing the full effect of magnetism at the minimum expenditure of current.

NEW INCORPORATIONS.

Lenox Gas and Electric Co., Lenox Mass., W. E. Plunkett, C. E. Merrill and others. Capital, $30,000.

Williamete Falls Electric Co., Portland, Oregon, D. P. Thompson, E. L. Eastman and others. Capital, $1,000,000.

Boonville Electric Light Co., Boonville, N. Y. Capital, $10,000.

Electric Light Co., Augusta, Ga., C. H. Phinizy, C. H. Oetjen and others. Capital, $50,000.

Osage City Electric Light Co., Osage City, Kan., J. B. Marshall and others. Capital, $15,000.

Truckee Electric Light and Power Co., Truckee, Col., W. H. Kruger and others. Capital, $10,000.

Mutual Electric Lighting Co., Jersey City, N. J., S. Marsh Young and others. Capital, $100,000.

Almonte Electric Light Co., Almonte, Ont. Capital, $20,000.

Paris Electric Lighting Co., Paris, Ky., C. S. Varden.

Newport Electric Light Co., Newport, Ky., John B. Taylor and others. Capital, $50,000.

Nebraska Electric Light and Motor Co., Omaha, Neb., D. B. Covell and others. Capital, $500,000.

Phoenix Electric Co., Marshall, Texas, J. H. Gates, John T. Johnson and others. Capital, $25,000.

Lee Electric Light Co., Lee, Mass., Wellington Smith, David Dunn and others. Capital, $10,000.

Ashland Electric Light and Power Co., Ashland, Oregon, H. B. Carter and others. Capital, $15,000.

Chicago Cork Insulating Co., Chicago, Ills., W. S. Driver, A. Ristin and others. Capital, $200,000.

Eastern Electric Construction Co., Portland, Me., G. C. Mosaes and others. Capital, $50,000.

American Fire Alarm Co., Portland, Me., C. F. Blackwell and others Capital, $20,000.

Beaver Electric Light and Power Co., Beaver Falls, Penn., W. H. Hartman and others. Capital, $12,000.

Oakland Electric Light and Motor Co., Oakland, Cal., W. E. Dargie, J. W. Cordes and others.

Cherryfield Electric Light Co., Cherryfield, Me., U. M. Nash and others. Capital, $7,000.

Buena Vista Electric Light Co., Buena Vista, Col., J. Tipton, C. S. Wood and others. Capital, $15,000.

Fort Worth Electric Manufacturing Co., Fort Worth, Texas. Capital, $100,000.

Carthage Electric Light and Power Co., Carthage, Mo., W. B. Myers, T. J. Rittenhouse and others. Capital, $30,000.

Plymouth Electric Light Co., Plymouth, Mass., G. F. Weston, C. E. Morton and others. Capital, $30,000.

Stout Electric and Storage Battery Co., New York, G. H. Stout, R. F. Hill and others. Capital, $200,000.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6¼	12	Sprague.
Allegheny, Pa	Observatory Hill Pass. Ry. Co	3.7	6	Bentley-Knight.
Ansonia, Conn.	Derby Horse Ry. Co	4	3	Van Depoele.
Appleton, Wis.	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	12	Daft.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Binghamton, N. Y	Washington St., Asylum & Park R. R	4.5	8	Van Depoele.
Boston, Mass	West End St. Ry. Co., Brookline Branch	12	20	Sprague.
Brockton, Mass	East Side Street Ry. Co	4¼	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	5	8	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	3	Daft.
Cleveland, Ohio	East Cleveland Railroad Co.	23¼	16	Sprague.
Columbus, Ohio.	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenport Central Street Railway Co	3¼	8	Sprague.
Dayton, Ohio	White Line St. R. R. Co	8.5	12	Van Depoele.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich.	Highland Park Ry. Co	8.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Fort Gratiot, Mich	Gratiot Electric Railway	1.75	2	Van Depoele.
Harrisburg, Pa	East Harrisburg Pass. Ry. Co	4.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	12	2	Sprague.
Ithaca, N. Y.	Ithaca Street Railway Co.	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind	Lafayette Street Ry. Co	2.25	8	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angelos, Cal	Los Angelos Elec. Ry. Co.	5	4	Daft.
Lynn, Mass	Lynn & Boston St. Ry. Co.	2¼	2	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18¼	10	Julien.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co.	9	12	Thomson-Houston.
Pittsburgh, Pa	Pittsburgh, Knoxville & St. Clair St. Railway	2¼		Daft.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Reading, Pa	Reading & Black Bear Ry.	1¼	2	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Richmond, Va	The Richmond Union Pass. Railway Co	13	40	Sprague.
Salem, Mass	Naumkeag Street Ry. Co.	1¼	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
St. Catherine's, Ont	St. Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	9¼	18	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	4.5	10	Thomson-Houston.
Scranton, Pa	Nayang Cross-Town Ry	3	4	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Syracuse, N. Y	Third Ward Ry. Co	4	8	Thomson-Houston.
Washington, D. C	Eckington & Soldiers' Home Electric Railway Co	2.7	3	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	10	Van Depoele.
Wichita, Kan	Riverside & Suburban Ry. Co	7	3	Thomson-Houston.
Wilkesbarre, Pa.	Wilkesbarre & Suburban Street Railway Co	3.6	7	Sprague.
Wilmington, Del	Wilmington City Ry. Co	6¼	13	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	1.5	2	Van Depoele.

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Alliance, Ohio		2	3	Thomson-Houston.
Asheville, N. C	Asheville Street Railway	8	4	Sprague.
Attleboro, Mass	Attleboro, N. Attleboro & Wrentham Street Ry. Co.	6		
Bangor, Me	Bangor Street Railway Co.	5	4	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets			Bentley-Knight.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	20	Thomson-Houston.
Buffalo, N. Y	Citizens' Electric Ry. Co			
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cincinnati, O	Cinc. and Inclined Plane Ry	6¼	20	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Danville, Va	Danville St. C. Co	2	4	Thomson-Houston.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	7¼	8	Thomson-Houston.
Elsinore, Cal	Elsinore Lake Shore Elec. Ry. Co			
Erie, Pa	Erie City Pass. R. R. Co	8¼	20	Sprague.
Flushing, N. Y	Flushing & College Point St. R. R	1		
Hudson, N. Y	Hudson St. Ry. Co	2.5	8	Thomson-Houston.
Lakeside, Ohio		3		
Lincoln, Neb	Lincoln Cable Ry. Co	5	10	
Louisville, Ky	Central Pass. R. R. Co		10	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co.	3¼	10	Sprague.
Minneapolis, Minn.	Minneapolis Street Ry. Co.	69¼	8	Sprague.
Newton, Mass	Newton Street Railway Co.	6		
New York, N. Y	North & East River Ry. Co.	3	20	Bentley-Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Ontario, Cal	Ontario & San Antonio Heights Ry. Co	8	4	Daft.
Ottawa, Ill		6	8	Thomson-Houston.
Philadelphia, Pa	Lehigh Avenue Ry. Co	6		
Port Chester, N. Y	P. C. & Rye Beach Street Railway Co	3	5	Daft.
Richmond, Va.	Richmond City Ry. Co	7¼	50	Sprague.
Rochester, N. Y	Rochester Electric Railway	9		
St. Joseph, Mo	Wyatt Park Railway Co	5	10	Sprague.
St. Louis, Mo	Lindell Railway Co		1	
Sacramento, Cal	Sac. Elec. Ry. Co. The Central St. Ry. Co	13		
Sault Ste. Marie, Mich.	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Street Ry. Co	4	6	Sprague.
Scranton, Pa	The People's Street Ry	10	20	Sprague.
Seattle, Wash. Ter	Seattle Electric Railway	5	5	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Springfield, Mo		2		Fisher.
Steubenville, Ohio	Steubenville Elec. Ry. Co.	2¼	10	
Sunbury, Pa	Sunb'ry & Northumberland Street Railway Co	3		Sprague.
Tacoma, Wash. Ter	Tacoma Street Railway	5	4	Sprague.
Topeka, Kan		14	30	Thomson-Houston.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.

Notes.

A short time ago the Julien Electric Co. expressed a hope that by their new method of regulations they could so economize the use of the current from their battery as to make three round trips, or thirty-six miles, with one charge on the Fourth and Madison avenues line. They now report that this has been accomplished, and that their large 18-foot cars, carrying unusually heavy loads of passengers, are now making three round trips, from 86th street to the Post-Office and back (or thirty-six miles), without any change of battery. They now change the battery but once a day, thus making a great saving in time. Not content with this performance the Julien company hope to be able to make a fourth trip, or forty-eight miles, on one charge, inasmuch as they find that at the end of the third trip the voltage of the battery is still above two volts per cell. It is claimed that the trip from 86th st. to the Post-Office and back, twelve miles, is made on an expenditure of less than 15 electrical horse-power hours, or thirty-six miles on 45 electrical horse-power hours. Calculating the cost at two cents per horse-power hour the Julien company compute that it costs but thirty cents for energy in a round trip of twelve miles, or two and one-half cents per mile. Assuming seventy-five miles for a car day the cost would be $1.87½. The company give these data from its books at their electrical station, and invite inspection, the records showing the ampere hours and the horse-power hours put into the battery each day, and the cost of the same.

AKRON, O.—The street railway, at Akron, Ohio, equipped with the Sprague system, has five cars in daily service, and one or two additional cars will soon be ready for use. Our report states that the management are much pleased with the operation of the road, and the excellence of the service rendered is a source of pride to the citizens. Recently, while descending a steep grade with a heavily loaded car the hand brake broke. The driver immediately reversed the motors and the car returned to the top of the hill.

BOSTON.—On the Boylston and Beacon street route of the West End Street Railway Co., the Bentley-Knight Co. have completed 1¾ miles of conduit. The extent of the work to be accomplished during the winter will be dependent upon the weather.

LEGAL NOTES.

THE ST. LOUIS TELEPHONE CASE.

SUPREME COURT, STATE OF MISSOURI.

The Ordinance of the City of St. Louis, Regulating Telephone Rates Declared Null and Void.

ABSTRACT OF OPINION BY JUDGE BLACK.

This was a prosecution against the Bell Telephone Co., of Missouri, for a violation of an ordinance which provides that "the annual charge for the use of the telephone in the City of St. Louis shall not exceed $50.00."

The defendant is a corporation organized under article 5, of chapter 21 of the revised statues of this state. They have the power to run and operate lines of telephone, to make reasonable charges for the use of same, to erect their poles along and across public roads and streets, to condemn private property for a right of way, and they are charged with the duty of receiving and transmitting messages with impartiality and good faith.

The defendant contends that the city has no right to fix a maximum rate of charges. The defendant's property, consisting of poles, wires, fixtures, and the like is, of course, private property; but the property is devoted to public use, and since the

defendant has conferred upon it special franchises and privileges, including the right of eminent domain, the corporation is subject to public regulations, and we shall take it for granted that the state has the power to fix and prescribe a maximum rate for telephone service. The important question is whether the City of St. Louis has the power to fix reasonable charges for telephone service. If the city has such power it must be found in a reasonable and fair construction of its charter. Judge Dillon makes this comprehensive statement of the rule as to municipal powers: (1) Those granted in express words. (2) Those necessarily or fairly implied in or incident to the powers expressly granted. (3) Those essential to the declared objects and purposes of the corporation—not simply convenient—but indispensable. The city places some reliance on its general power to regulate the use of streets. This power extends to new uses which spring into existence from time to time, as well as to uses known at the time of the dedication or grant of power to the municipality.

That the company is subject to reasonable regulations by the city as to planting its poles and stringing its wires and the like, is obvious. Conceding all this, we are at a loss to see what this power to regulate the use of the streets has to do with the power to fix telephone rates. * * * But taking these charter provisions together, we think it would be going to an extreme length to say that they confer upon the city the power to fix telephone rates. If it has the power to do this, it may also fix the charges for telegraph services, which are of a public character.

We conclude that the city has no power to pass the ordinance in question by reason of any of the charter powers before considered. This conclusion is manifest when we consider that the charter points out with particularity those cases in which the city may fix rates and charges. Judgment accordingly.

STORAGE BATTERY PATENTS.

The Julien Electric Co. make the following statement:—

"The commissioner of patents at Washington has just rendered a decision supporting Mr. Julien's claim for an inoxidizable alloy as against the claim of the Faure-Sellon-Volckmar combination.

"The Electrical Accumulator Co., of New York, with a view no doubt of testing the validity of Mr. Julien's patent, filed an application in the patent office some time ago for a patent, claiming among other things an alloy containing lead and antimony for a support plate in a secondary battery. The patent office, thereupon put them in interference with the Julien Electric Co. Much expert evidence was offered on both sides. Professor Morton, Mr. Reckenzaun and Mr. Madden testified on behalf of the Electrical Accumulator Co., and Professor Barker, Dr. Van der Weyde and Mr. Salon testified on behalf of the Julien Electric Co. The case was then argued before the commissioner by able counsel on both sides, and the commissioner after due consideration decided in favor of the Julien Electric Co., holding that an alloy of lead and antimony had no novelty, but that an alloy of lead, antimony and mercury, as claimed by Mr. Julien, has specific advantages and novelty.

"It was proved on behalf of the Julien Electric Co., and it has been admitted by the examiner in his opinion, that while an alloy of lead and antimony has serious disadvantages as a support plate by reason of the crystalline structure of the metal making it liable to oxydation and consequent disintegration, yet the presence of mercury removes this defect and makes the alloy homogeneous and practically inoxidizable.

"This decision is not only a great triumph for the Julien Electric Co., but is of widespread interest to the electrical community, who we all know are looking forward to a storage battery constructed on scientific principles."

The following statement is from the Electrical Accumulator Co.:

"A public statement from the Julien company has appeared, which it is made to appear that the application of the Electrical Accumulator Co. for a certain patent has been refused by the United States Patent Office. Such a statement is not true; on the contrary, the commissioner of patents, Washington, has just rendered a decision sustaining the claims of John S. Sellon as the inventor of an inoxidizable alloy support plate, and Mr. Sellon's patent has been passed to issue, and will shortly appear on the patent records duly assigned to the Electrical Accumulator Co. The application of Sellon was founded upon the specification of his English patent No. 3,987, dated September 15th, 1881. This British patent of Sellon's is the first publication to describe the use of a plate of lead and antimony, or an alloy of two metals, either with or without the use and application of an amalgam as a support for the active material in a battery of the Faure type.

"Immediately following the decision of the commissioner above referred to, a second application of Sellon's claiming an alloy of two or more metals and an amalgam, was placed in interference with Julien's patent. It will thus be seen that litigation up to this date in the patent office, has resulted in the substitution of Sellon's second application for the first application which was placed in interference on the allowance or passing of Sellon's first application to issue.

"The issue of this patent in the United States will enable the assignee of Sellon, the Electrical Accumulator Co., to control the manufacture, use and sale of secondary batteries employing lead and antimony in the composition of the support plates, whether mercury to form an amalgam be present or not, and suits will be instituted in the courts for the recovery of damages at once."

THE RELATIONS OF FOREIGN TO U. S. PATENTS.

MR. H. PALM (Michalecki & Co.), civil engineer and patent agent, Vienna, has kindly sent us the following communication, which will be found of much interest to all who are interested in inventions patented both in the United States and abroad:—

Dear Sir—In an actually pending patent suit, a court of justice of first instance in the United States of America has declared Austro-Hungarian patents for which, on filing the application, the fee has been paid for one year only, to be one year patents, in consequence whereof a United States patent, granted for the same invention, after the grant of the Austro-Hungarian patent, would likewise have a duration of one year only. In consideration of this fact, it cannot fail to be of interest, to learn the wording of an official declaration given by the Austrian Imperial Royal Ministry of Commerce in reply to a request presented by the Austrian attorney of the patent proprietor against which the judgment of the United States court had been pronounced. This official declaration runs as follows:

Imp. Roy. Ministry of Commerce.
No. 21,893.

OFFICIAL CONFIRMATION.

By these presents, the Imp. Roy. Ministry of Commerce in Vienna confirms:—

1st. That, according to § 25 of the Imperial Charter of the 15th August, 1852, No. 184 of the Bulletins of Laws of the Empire, the term of the longest duration of any patent granted, without exception, is limited to 15 years, this duration running on uninterruptedly, provided that the patentee complies with the conditions mentioned under 2; — that this primitive term of 15 years belongs, without exception, to every patent granted under the provisions of the Imperial Charter of the 15th August, 1882, No. 184 of the Bulletins of Laws of the Empire;

2d. That, according to § 11 of the Patent Law, the patentee is not bound to pay at once, in advance, the fee for all 15 years, but that he is permitted to pay the fee by annuities;

3d. That, on the patent documents of an Austro-Hungarian patent granted under the provisions of the law referred to hereinbefore, the mention of one or more years, beside the authentication of the grant of the patent, exclusively purports to confirm, that the patent fee annuities have been paid in advance for one or more years, and that hereby the term of the granted patent is in no way affected, as this term, according to the above statement, is limited to 15 years by the law.

4th. That, when the patent fee is paid in annuities, viz., from year to year, the several payments do not bring about an extension of the duration of the patent, as this duration is fixed, from the origin, according to the law, but these payments only prevent the cease of the patent before the expiration of the term of 15 years, for which it has originally been granted, on the ground of the patentee failing to pay the prescribed fee;

5th. That the Imp. Roy. Ministry of Commerce in order to prevent erroneous interpretations relatively to the term of Austro-Hungarian patents by foreign authorities, has felt induced as early as in July, 1884, to replace the printed blanks of patent documents, then in use, by other blanks, which leave no doubt as to the term of an Austro-Hungarian patent.

THE IMP. ROY. MINISTRY OF COMMERCE.

Vienna, the 18th July, 1887.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From November 20 to December 18, 1888 (inclusive).

Alarms and Signals:—*Electric Alarm System*, W. F. Rossbach, 393,078, November 20. *Electric Light Burglar-Alarm Indicator*, R. Packer and I. E. Cochran, Jr., 393,657. *Electric Bell*, A. Lungen, 393,710, November 27. *Electric Bell*, J. F. McLaughlin, 393,996. *Electric Annunciator-Target*, F. J. Patten and T. A. Bingham, 394,081, December 4. *Electric Alarm and Water Gauges*, J. H. Johns, 394,491, December 11. *Annunciator*, W. C. Clark 394,555. *Electric Signaling Apparatus*, G. F. Milliken, 394,784. *Magneto-Generator for Fire-Alarm Circuits*, W. L. Denio, 394,839. *Electric Push Button*, A. J. Hoyt, 394,925, December 18.

Clocks:—*Synchronizing Mechanism for Clocks*, E. Kronenberg, 393,159, November 20. *Electric Striking Attachment for Clocks*, J. H. Gerry, 393,637. *Pendulum-Regulator for Clocks*, same, 393,638, November 27.

Conductors, Insulators, Supports and Systems :—*Conduit for Electric Conductors*, J. Kames, 393,018. *Insulating Composition*, A. Poitevent, 393,-099. *Underground Conduit for Electric Conductors*, C. J. Van Depoele, 393,-276. *Arched Suspender for Overhead Electric Conductors*, same, 393,317. *Electrical Conduit*, J. Whelan, 393,346, November 20. *Art of Laying Underground Conduits*, W. Lake, 393,477. *Non-Conducting Composition* S. Heimann, 393,644, November 27. *System of Suspending Electric Conductors*, C. J. Van Depoele, 394,039. *Submarine and Subterranean Electric Cable*, E. Flotron and F. B. A. R. De la Bastie, 393,823, December 4. *Electric Underground Conduit*, D. O. Paige, 394,207. *Wire Holder for Insulators* E. L. Lloyd, 394,380, December 11.

Distribution :—*Transformation and Distribution of Electrical Energy*, W. J. McElroy and T. J. McTighe, 393,073. *Distribution of Electricity by Secondary Batteries*, H. Edmunds, 393,147, November 20. *Distribution of Electricity by Secondary Batteries*, W. W. Griscom, 393,470, November 27. *Electric Distribution by Secondary Batteries*, Z. Latshaw, 394,541, December 11. *Distribution of Electricity by Secondary Batteries*, T. P. Conant, 394,642. *Conveying Electric Energy*, S. Z. De Ferranti, 394,837 and 394,838, December 18.

Dynamos and Motors :—*Electric Motor and Dynamo*, A. L. Riker, 393,266. *Switch for Electric Motors*, G. H. Condict, 393,323, November 20. *Electric Motor*, F. J. Keller and J. W. Carnes, 393,373. *Oiler for Commutators*, T. E. Craig, 393,422. *Regulatiou of Alternate-Current Generators*, G. Pfannkuche, 393,448. *Dynamo-Electric Machine*, W. W. Griscom, 393,469. *Regulator or Cut-off for Generators*, D. W. Smith, 393,590. *Dynamo-Electric Machine and Electric Motor*, W. P. Freeman, 393,636, November 27. *Electric Motor*, C. J. Van Depoele, 394,035. *Duplex Electromotor*, same, 394,036. *Electric Motor and Dynamo-Electric Machine*, O. Lugo, 394,075. *Commutator*, C. L. Buckingham, 394,095. *Dynamo-Electric Machinery*, W. F. Collins, 393,742. *Armature for Dynamo-Electric Machines*, L. Daft, 393,745. *Dynamo-Electric Machinery*, S. E. Nutting, 393,849, December 4. *Safety Device for Electric Motors*, C. J. Van Depoele, 394,417. *Safety Device and Signal for Electric Motors and Generators*, same, 394,525, December 11 *Dynamo-Electric Machinery*, C. S. Bradley, 394,818 and 394,819. *Dynamo-Electric Machine*, G. W. Riethmann, 394,883. *Armature Core for Dynamo-Electric Machinery*, W. S. Belding, 394,905, December 18.

Galvanic Batteries :—*Galvanic Battery*, F. H. Root, 393,123. *Gravity Battery*, L. C. Bartley, 393,203, November 20. *Porous Cup for Galvanic Batteries*, H. J. Brewer, 393,353. *Galvanic Battery*, H. L. Roosevelt, 393,395 ; J. L. Gethins, 393,639, November 27 ; P. C. Burns, 393,814, December 4. *Separating-Partition for Galvanic Batteries*, I. L. Roberts, 394,613. *Separating-Diaphragm for Galvanic Batteries*, same, 394,614. *Treating Diaphragms and Cups for Use in Electric Batteries*, same, 394,615. *Diaphragm for Galvanic Batteries*, same, 394,616 and 394,617. *Separating-Partition for Galvanic Batteries*, H. L. Brevoort and I. L. Roberts, 394,638. *Galvanic Battery*, R. D. Wright, 394,670. *Carbon Electrode for Electric Batteries*, J. Beattie, Jr., 394,810, December 18.

Ignition :—*Electric Gas Lighter*, C. H. Haskins, 393,304, November 20. *Automatic Gas Lighting and Extinguishing Apparatus*, N. H. Shaw, 393,525, November 27. *Electrical Fuse*, J. Macbeth, 394,192, December 11.

Lamps and Appurtenances :—*Electric Light Pole*, E. Thomson, 393,040, November 20. *Filament for Incandescent Lamps*, G. S. Ram, 393,391. *Arc Light*, D. B. Turner, 393,405. *Electric Arc Lamp*, G. Pfannkuche, 393,447. *Incandescing Electric Lamp*, E. H. Johnson, 393,473. *Electric Light Regulator*, L. Paget, 393,574. *Globe for Electric Lamps*, S. Heimann, 393,704. *Incandescent Electric Lamp Socket*, W. F. Wollin and E. H. Werline, 393,733, November 27. *System of Electric Lighting*, W. W. Griscom, 393,756. *Train-Lighting by Secondary Batteries*, same, 393,757, December 4. *Lamp Hanger*, D Chisholm, 394,153. *Cut-Out for Electric Lamps*, C. Heisler, 394,180, December 11. *Support for Incandescent Electric Lights*, A. Dawes, 394,680. *Electric Arc Lamp*, R. Schefbauer, 394,791, December 18.

Measurement :—*Instrument for Measuring Electric Currents*, A. G. Waterhouse, 393,063. *Electric Meter*, F. C. Wagner, 393,132 ; W. F. Stocker, 393,315, November 20 ; A. Reckenzaun, and J. A. Pentz, 394,880 ; A. Reckenzaun, 394,-881, December 18.

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EXPIRING PATENTS.

Patents relating to Electricity which become Public Property in January 1889.

Reported for the ELECTRICAL ENGINEER, *by* F. B. Brock, *Patent Attorney*, 639 *F street, Washington, D. C.*

Gas Lighting, Electric,	W. Klinkerfues,	122,389, Jan. 2, 1872.	
Indicators, Electric,	S. Chester,	122,437	"
Automatic Telegraphs (2 patents),	G. Little,	122,473 122,474	" "
Therapeutic Bath,	S. Pasco,	122,486	"
Separators, Magnetic,	A. Ross,	122,493	"
Electric Motor,	H. S. Daggett,	122,572, Jan. 9, 1872.	
Telegraph Pole,	T. Rogers,	122,656	"
Electric Annunciator,	G. B. Scott,	122,664	"
Printing Telegraph,	H. Van Hoevenbergh,	122,687	"
Electric Burglar Alarm,	Rowell & Duncan,	122,913 Jan. 23, 1872.	
Electric Motor,	C. V. Gaume,	122,944	"
Telegraph Poles,	McDonald & Crandall,	122,952	"
Insulators, Electric,	C. H. Pond,	122,961	"
Printing Telegraph (2 patents),	T. A. Edison,	123,005 123,006	" "
Electric Insulator,	J. Robertson,	123,198 Jan. 30, 1872.	
Electric Regulators,	Wells & Moran,	123,315	"

[Drawings and specifications of any patent will be furnished by Mr. Brock at cost, 15 cents each.]

THE

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VOL. VIII. NEW YORK, FEBRUARY, 1889. No. 86.

THE EFFECT OF THE SUPREME COURT DECISION.

THE decision rendered on January 21st, by the Supreme Court of the United States in the case of the Bate Refrigerator Co. against Hammond, involving the determination of the question as to the effect of the existence of a foreign patent upon the term of a patent subsequently issued in the United States to the same inventor, having excited an especial degree of interest in electrical circles, we have reprinted it in full in another part of this issue.

The case arose upon the construction of Section 4887 of the Revised Statutes, the language of which is as follows :—

Sec. 4887. No person shall be debarred from receiving a patent for his invention or discovery, nor shall any patent be declared invalid, by reason of its having been first patented or caused to be patented in a foreign country, unless the same has been introduced into public use in the United States for more than two years prior to the application. But every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one, at the same time with the one having the shortest term, and in no case shall it be in force more than seventeen years.

The difficulty in construing the statute arises from the circumstance that certain foreign countries grant patents for a short term of from one to six years, which may be extended upon the payment of certain fees and after compliance with certain statutory provisions.

The facts in the present case were these :—A patent was granted to the inventor in the United States on November 20th, 1877. He had, however, obtained a patent in Canada for the same invention on January 9th, 1877, although the application for the Canadian patent had not been made until after the application in this country. The Canadian patent was originally granted for a term of five years and was afterwards extended to the full term of fifteen years. The Circuit Court of Massachusetts held that the meaning of the section of the Revised Statutes above quoted is, that any United States patent granted after the issue of a foreign patent, expires with the foreign patent. This and other Circuit courts have held in other cases as well as in the Bate case that the original Canadian term of five years was controlling, and that the United States patent expired therewith whether that term had been extended or not.

The Bate case having been appealed and placed upon the calendar of the Supreme Court, the Edison Electric Light Co., a number of whose most important patents were similarly circumstanced, arranged with the Bate company to lend them the assistance of counsel in arguing the case before the Supreme Court. In due course the Bate case could hardly have been reached for two or three years to come, but through the persistent efforts of the counsel of the Edison company the Supreme Court permitted the substitution of the case for another one near the head of the docket and about to be heard. The Bate case was accordingly argued on January 2, 3, and 4, by William M. Evarts and Clarence Seward for the appellants and Chauncey Smith, B. F. Thurston and G. H. Lothrop for the appellees. A brief was also filed in behalf of the United States Electric Lighting Co., the Westinghouse Electric Co., the Consolidated Electric Light Co., the Thomson-Houston Electric Co. and the Fort Wayne Jenney Electric Light Co., the business of all these companies being supposed to be affected in some manner by the result of the decision.

The principal points contended for by the counsel for the appellees, were, first : that the statute applies to patents for inventions patented abroad before the *grant* of the patent here, and not merely to patents for inventions patented abroad before the date of the *application* here ; and second : that it limits the term of the domestic patent by the current term of the foreign patent existing at the time of the domestic grant, without regard to any subsequent extension or curtailment dependent upon uncertain events.

The first of these questions is really the important one, and it is on some accounts to be regretted that the Court did not find it necessary to decide it explicitly but left it to stand as heretofore interpreted by the Circuit courts. With respect to the second point, the established principle that the American patent shall expire with a prior foreign patent is reaffirmed ; but, in contravention of the opinion of the lower court, the Supreme Court holds that the Canadian patent, by reason of having been extended, has never actually expired.

The effect of the decision is, in short, that the term of the domestic patent is determined by the duration of the uninterrupted term of the prior foreign patent. The exact language used is, that " it is to be in force as long as the foreign patent is in force." The language of the decision clearly implies that the extended or prolonged term of the foreign patent must be continuous with the original grant, and hence the occurrence of any interregnum would be fatal to the domestic patent. Incidentally, it is affirmed that the limitation need not be expressed on the face of the

domestic patent, although the contrary has been held in at least one instance in the lower court.

The real importance of this decision appears to us to have been very much overrated by the newspapers, although there is no doubt that the position of some of the leading electric lighting companies, notably the Edison and the United States companies, has been materially strengthened by it. Indirectly, we think it will have a beneficial effect upon all the stronger electric companies, as increasing the actual value of all property and industries founded upon patents.

PATENT OFFICE REFORM.

The New York *World* has during the past few weeks published a number of articles reflecting severely not only upon the general plan of organization of the United States Patent Office but upon the capacity and integrity of the examining force. Not only are general charges of inefficiency and corruption freely made, but in some instances the allegations are aimed at specific persons. A great number of inventors, attorneys and patent solicitors of more or less prominence, have also been "interviewed," and the remarks attributed to them are, in some cases at least, rather spicy reading. On the whole, however, their testimony is rather in favor of the employés of the Patent Office than otherwise. It is especially noticeable that those patent solicitors of the highest standing in their profession, who handle cases involving the most important and valuable inventions, were the ones who had the least fault to find with the examiners as a body, while others, especially one or two whose incapacity may fairly said to be abnormal, improved the occasion to criticise and denounce the office, the system, and every person connected therewith, in the most unmeasured terms.

That mistakes, delays, and obstructions of the most exasperating nature, too frequently occur during the passage of applications through the Patent Office, no one is more ready to admit than many of the examiners themselves, but they nevertheless contend, and with much justice, that in most cases the fault is inherent in the organization of the office, and does not lie primarily with themselves, in short, that the remedy rests with Congress, and not with the Commissioner of Patents.

The writer has become quite familiar, by many years of experience, with the workings of the Patent Office in one of its most difficult classes, that of electricity, and has prosecuted a large number of applications, many of them involving very large commercial interests, usually to a successful issue. Of course, this has in many instances not been done without friction, and even in the face of positive and unnecessary obstruction. We have known a device, as ingenious as it was simple, and as novel as it was useful, to be rejected no less than 13 times, only to be finally allowed and patented exactly as it was originally presented. But, nevertheless, we must in justice to the examining corps place upon record the fact that with rare exceptions, we have found them to be courteous, intelligent, and, above all, honest. We have never had reasonable ground for suspicion that adverse influences of an improper character were enlisted against us. On the other hand, it gives us pleasure to acknowledge, some of the most valuable claims we have ever taken from the office have been due to the criticisms and suggestions of well-informed and experienced examiners. Even the "obstructionists" found here and there among the incumbents, who are so heartily anathematized by the unfortunate solicitor who happens to collide with one of them, like most objectionable things, are not wholly without their uses. Many a specification or claim has been wonderfully improved by the careful scrutiny, the frequent rewriting, or the novel method of presentation necessitated by the perverse, stupid and ignorant objections of some callow youth, inflated almost to bursting with a superabundance of that extraordinary form of energy, which for want of a better name, we term "officialism." In short, we have rather felt that we had cause to be thankful that so efficient and capable a body of men as the examiners generally could be found, and retained for a reasonable time in the service upon such inadequate compensation. The electrical class has been peculiarly fortunate in this respect, and we can only hope that we will fare no worse hereafter than we have done heretofore.

For our own part we agree substantially with the opinion attributed by the *World* to Mr. E. S. Renwick, and concurred in by many others whose views are entitled to great weight, which, in effect, is that the present system of examination, while it has served fairly well in the past, must inevitably break down from its own weight at no distant day, in consequence of the enormous and rapidly increasing aggregation of inventions in all parts of the world, all of which, in each class, must in theory at least, be compared with every new invention which is presented to the office for examination.

It is probable that the best attainable plan will be found to be one in which the Commissioner has no power to refuse a patent for an application when presented in proper form, so as to contain a "full, clear and exact description" of the invention, and a definite statement of what is claimed to be new. Examination should be made, as fully and carefully as possible, and a reference to all alleged anticipating publications, public uses, etc., discovered in this way, should be printed and annexed to the patent, thus enabling every person to do what careful persons always do now before dealing with a patent, that is, examine the references cited by the examiner and judge for himself of their pertinency and importance.

Some plan ought also to be devised which will do away with the whole system of trying interference cases in the Patent Office, and relegate them immediately to the existing Federal courts or to a separate patent court such as the Court of Patent Appeals for the establishment of which the congressional bill introduced last year made adequate provision.

It is to be hoped that the agitation commenced by the *World* will result in awakening Congress to some sense of its duties towards the Patent Office, and towards the inventors of America, a matter quite as important to the country as the question of the tariff.

.... In 1875, it was thought wonderful to transmit messages to Ireland, at 80 words a minute. When I was recently in Belfast, I timed messages coming at the rate of 461 words a minute.—*W. H. Preece.*

THE EDISON CONSOLIDATION.

The incorporation, under the laws of New Jersey, of the Edison General Electric Co., with a capital stock of $12,000,000, marks the consummation of the negotiations which were the basis of the rumors and newspaper gossip current a few weeks ago.

The new company takes over the plant and business of the several Edison manufacturing companies, namely : The Edison Machine Works, Schenectady, N. Y., the Edison Lamp Co., East Newark, N. J., and Bergmann & Co., New York. It also acquires the property and business of the parent organization, The Edison Electric Light Co., and supplants the Edison United Manufacturing Co. in the trade in isolated plants. A large amount of new capital has been put into the new company, furnished, it is understood, by a syndicate through Mr. Henry Villard, whose part in the transaction attracted so much notice by the daily press a month ago.

The Edison General Electric Co. will thus own and manage the entire Edison interests in electrical distribution and lighting. It is further announced that branch offices will be established in all the leading cities, and that the erection and operation of local central station lighting plants will be a prominent feature in the business of the new company.

The large accession of capital and the more compact organization attending these changes, together with the considerably improved position of some of the Edison patents resulting from the recent decision of the United States Supreme Court in the Bate refrigerator case, add material strength to the position of the Edison interests in the competition with their energetic rivals in the business of electric lighting.

ELECTRICAL EXECUTIONS.

On the occasion of his address to the Electric Club of New York, December 20th, Professor Brackett expressed the opinion that no criminal would ever be executed by the agency of electricity in this state notwithstanding the legislation ordaining that method of execution upon the perpetrators of capital crimes committed after the first of January, 1889. We are inclined to agree with Professor Brackett in his opinion for several reasons. It is much easier to get laws made than to put them in operation, and the proposed change has apparently no popular support. The legislation ordaining it seems ill-considered, being based upon a very inadequate report by the commission appointed "to investigate and report the most humane and practical method of carrying into effect the sentence of death in capital cases." In the matter of bulk the report is more than adequate, but it fails to show that execution by electricity is either the most humane or the most practical method to be found. It is not shown to be more humane than the administration of a sudden poison, gaseous or liquid, and it is certainly much less convenient. How far electricity is from being the "most practical" method is well illustrated by the toilsome months occupied by the Medico-Legal Society in their efforts to discover the best mode of applying it. Although a special committee of that society has investigated the subject with the assistance of such electricians as it could interest in the matter, and has made two reports, it is not quite sure yet as to the best method, beyond recommending a minimum capacity of dynamo and an alternating current. Notwithstanding the excellent motives of the humane gentlemen who initiated and promoted the legislation of last winter we do not believe their plan will succeed.

It is sensational and mysterious to the general public. It is too experimental in character to commend itself to the calm judgment of penologists and legislators. The act ordaining it would better be repealed than put in operation.

RIVALS UNITED.

The arrangement between the Westinghouse Electric Co. and the United States Electric Lighting Co., announced a few days since, proves to be to all intents and purposes a consolidation of the two interests under the control and management of the first-named organization. The United States is one of the oldest and best known electric light companies in the country. It has always done a large business, but has been seriously handicapped by the unfortunate necessity incident to many pioneer enterprises of expending large sums of money not only in experimenting and in litigation, but in the reconstruction of its early plants in order to keep pace with the rapid progress and development of invention. It has, moreover, borne a large share of the costly burden of educating a skeptical public to appreciate the manifold advantages of electric illumination, and of overcoming the endless legal and other obstructions due to ignorance and prejudice, labors which, while necessary and unavoidable, are by no means pecuniarily profitable. The value of the service thus rendered by the United States Company to electric interests has been but scantily appreciated, even by those who are profiting most largely by it at the present day. The union of its fortunes with those of a strong and energetic concern, like the Westinghouse company, will enable the United States stockholders to reap something like a fair share of the results of their own labors and sacrifices. This consolidation is but another proof of the inevitable tendency of events, which we have frequently pointed out, towards an ultimate union of the important electric light companies under a common executive management. Practically the present consolidation leaves but four strong organizations in the field, if we except the Western Electric Co., which, of late, manifests indications of an intention to increase the scope of its great general electric business, by taking a larger part than heretofore in the field of electric light and power at some future and not very distant day. The electric lighting business, on the whole, appears to be rapidly getting down to a business basis.

The press despatches sent from Washington announcing the decision of the Supreme Court in the Bate patent case were, if possible, even more contradictory and ambiguous than usual in their statements of the points really covered by the decision ; nevertheless the reporter of a leading New York evening paper promptly started out to interview various persons of more or less prominence to obtain their views on the matter. Among others the scribe called upon

the secretary of the Edison Electric Light Co., who is said to have exclaimed with youthful enthusiasm :—

"The decision in the Bate case covers exactly the same points upon which nearly one hundred of our most important lawsuits depend. This decision simply means that the only defense set up by our rivals is now broken down. It practically assures us a monopoly of the incandescent lighting system. * * * * Our competitors are virtually all knocked out, and are worse off even than if they had never begun business." But, unfortunately, when the full text of the decision came to hand it turned out to be a horse of another color altogether. The point vital to the Edison company, and the one which had been strenuously urged by them from the beginning, was that the statute of limitation did not apply to patents for which the *applications* in this country had been made prior to the date of the foreign patents, the contrary having been held by the Circuit courts in at least four important cases since 1882. The Supreme Court, it now appears, expressly declines to reverse the Circuit court decisions upon this point, and hence the law remains unchanged on that point. If the Edison company had been fortunate enough to secure a favorable decision in this particular, it would certainly have gone a long way towards giving them the monopoly hoped for ; but, as it is, the result though of unquestionable benefit to it, is beneficial also to some of its most aggressive rivals, while so far from overthrowing the only defense set up by competitors, it merely puts the company in the position to institute suits which must be tried on their merits in the usual tedious and expensive manner. It was largely with a view of avoiding lengthy and costly litigation that the companies opposed to the Edison interests sought to make a short cut by joining in the appeal of the Bate case. It is such a very long way out of the woods yet that much of the crowing heard during the past week seems scarcely justified by the facts as they exist.

It is announced that the authorities of Columbia College have undertaken the establishment of a course in Electricity and Electrical Engineering. This should be welcome intelligence to young men seeking such training and to the managers of the large industrial companies founded upon applications of electricity. Several high class technical schools have successfully established such courses, but more are needed. It still remains true that the great electrical companies find it difficult to secure a sufficient number of men equipped with the theoretical knowledge requisite to direct and supervise the technical part of their work. The Columbia School of Mines has demonstrated its capacity to train mining and civil engineers and, it may safely be assumed, will be no less successful in the projected new department.

The meetings of the Institute of Electrical Engineers during the present season are proving to be of much interest and importance. The paper of Mr. E. G. Acheson, January 8, on "Lightning Arresters and the Photographic Study of Self-Induction" which we print in full in this issue, was timely and very suggestive in view of much recent discussion of related topics by prominent investigators. At the meeting of February 12, Lieut. F. Jarvis Patten will read a comprehensive paper on Multiplex Telegraphy, including an account of his own recent work in that field. In March, Professor E. L. Nichols, of Cornell University, is expected at the Institute meeting with a paper on "The Efficiency of Methods of Artificial Illumination."

The half-yearly convention of the National Electric Light Association, to be held at Chicago, February 19, 20 and 21, not only promises to be unusually well attended, but in the matter of exhibits will no doubt far outstrip any previous convention. With characteristic enterprise the western members of the executive committee, headed by Mr. B. E. Sunny, have exerted themselves to make the exhibition a success in the variety and extent of the apparatus and supplies to be shown, as well as in the accommodations for displays and their convenient inspection by members of the association and visitors.

We have much pleasure in re-printing Professor Brackett's striking address of December 20th, before the Electric Club of New York, notwithstanding the lapse of time since its delivery. The address touches several important and timely topics in a peculiarly suggestive and felicitous manner. Our reprint has the advantage of the correction by Professor Brackett of several errors found in its earlier publication elsewhere.

Our congratulations are extended to Mr. T. Commerford Martin and Mr. Clarence E. Stump, upon their acquisition of a proprietary interest in the W. J. Johnston Co., Limited, which corporation succeeds Mr. W. J. Johnston, in the publication of the *Electrical World*, from January 1, 1889.

The next Semi annual Convention of the Association of Edison Illuminating Companies will be held at Kansas City, Mo., on Tuesday, February 12th. Accommodations have been arranged for the members of the Association at the Coates House, Kansas City.

OBSERVATIONS.

The daily press has unearthed another prior inventor of the telephone. In a special despatch to the Associated Press—dated Des Moines, Ia., one P. N. Pease is reported to claim the original invention of the telephone. The despatch goes on to say :—"He produces evidence to substantiate his claim which will be investigated by the Patent Office. Pease began experimenting in 1855, his efforts were crowned with success in 1857, and in that year he filed a caveat in the Patent Office, under the name of the Electric Musical Telephone. Later he perfected a telephone, and in 1872 his invention was described in a book entitled, "Wonders of Electricity." It will be seen that there is nothing mean about Pease. It is not surprising that he originally invented the telephone. Many persons have done that. But to have discovered that the description of the suggestion of Bourseul and the work of Reis, found in the "Wonders of Electricity," really means Pease, shows genius of an abnormally high order. The only moneyed men, we fear, who will take stock in Pease will be those who don't know beans.

However, there is no reason why Mr. Pease should'nt step into line with the rest. Let us have Pease.

There is lots of fun in reading over books which incidentally give what they suppose to be information concerning electrical subjects. Looking over an old bookstand the other day, the observer picked up a book entitled "Sunshine and Shadow in New York." Turning over the leaves revealed the date of publication, 1868, and disclosed a description of the New York main telegraph office at 145 Broadway. The author wrestles with the switch-board as follows :—

"A curious instrument is used in the American company's office, which is called a telegraph switch, operating somewhat like a switch on a railroad track. With it, a message can be switched off at any moment, at any point, to let an incoming despatch have the track.

ARTICLES.

A SKETCH OF THE HISTORY, DEVELOPMENT AND PRACTICAL APPLICATION OF THE ELECTRICAL CONDENSER.

BY WM. MAVER, JR.

(Continued from page 21.)

PART II.

A SOMEWHAT generally adopted method of arranging the plates and dielectric of the modern condenser is that devised by Varley, in which one corner of the plates of tin-foil, A and B, and two corners of the dielectric C, are clipped, as in figure 6. Each series of plates of tin-foil is placed with the cut corners together; the cut corners of each

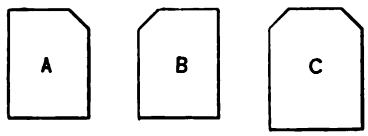


Fig. 6.

alternate series of plates being placed on opposite sides, with the dielectric between and extending beyond the edges except at the clipped corners. This arrangement permits the plates of each series to be readily connected together without danger of short-circuiting with the alternate series. Another method is frequently employed in which all the sheets of foil are placed evenly throughout, and a small strip of tin-foil inserted between each sheet of tin-foil and the dielectric, the strips of the alternate plates being then connected together.

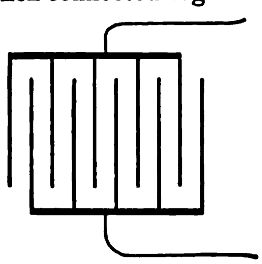


Fig. 7.

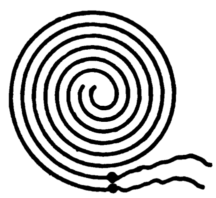


Fig. 8.

There are two general forms or shapes into which the sheets of foil and dielectric are arranged, namely, the flat and cylindrical—figures 7 and 8. These forms are, however, varied as to length, width and thickness, to any desired extent.

One of the latest improvements in the arrangement of the condenser is found in the Marshall multiple-series condenser, in which the different sections can conveniently be placed in series or multiple or in a combination of both or entirely separate one from the other. A diagram of the connections of this arrangement, which represents such a condenser having ten sections, is shown in figure 9. The manner of connecting the plates to the brass strips 1, 2, 3, etc., is shown in three instances in the figure. D E are the usual metallic connecting strips. In the figure three sections of plates are shown connected in multiple arc, by the insertion of plugs. Sections 8 and 9 are joined in series by means of a piece of wire and binding posts similar to that shown separately in the figure. Section 7 is shown as discharged or short-circuited by the insertion of a plug between the two strips, and section 5 is shown as being used independently of the other sections. Assuming the capacity of each section to be .1 M. F., this condenser would have a range of from 1. M. F. to .01 M. F., besides being capable of providing, if necessary, ten separate condensers of .1 M. F. each.

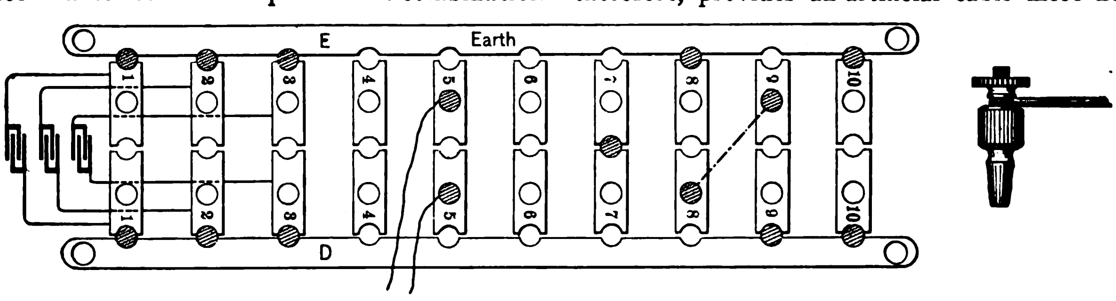


Fig. 9.

The condenser as used in frictional electric gas lighting machines is somewhat different in construction from the ordinary modern condenser. It is composed of a few sheets of tin-foil separated by thin sheets of hard rubber, the outside foil being covered also with hard rubber, the whole not being over .25 inch thick. A condenser of this form about one foot square will accumulate from the plate-electric machine of the apparatus a charge sufficient to produce a spark two inches long.

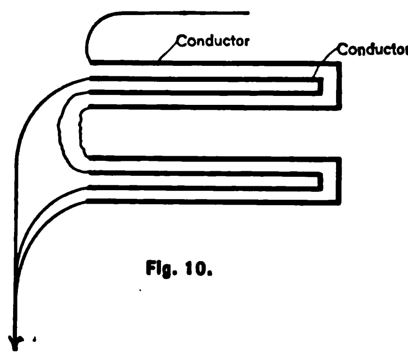


Fig. 10.

Another form of condenser is that known as the Muirhead artificial cable. In this arrangement one plate or side of the condenser is used as a conductor, and it is joined in a continuous strip. The other plate is also joined in one continuous strip and is connected at both ends to the earth, figure 10, the strips being separated by the usual dielectric. The strip used as the conductor is so proportioned that it shall equal in resistance and electro-static capacity the cable of which it is the counterpart. This form of condenser is the one now almost universally used on long submarine cables.

One form of the Varley artificial cable was constructed of a plain resistance along which, at stated intervals, condensers were placed. The result of this arrangement, as shown by Varley himself, is that an irregular distribution of the charge occurs on the artificial cable. In a "main" cable the distribution of charge is regular from the maximum point of potential to zero. The Muirhead device therefore, provides an artificial cable more nearly corresponding to the "main" cable, than the Varley, or as it is sometimes called, the Stearns' artificial cable, and consequently permits a more perfect balance between the main and artificial cables, and increased efficiency in duplex telegraphy.

One of the first practical applications of the condenser of the sheet form was its use in the Ruhmkorff coil. Even as first constructed its beneficial effect in amplifying the

spark of the secondary coil and diminishing the destructive spark at the contact point of the circuit breaker was very marked. Although apparently simple of explanation none of the theories yet propounded as to the action of the condenser in performing this function, has, I believe, been definitely accepted as the correct one.

M. Fizeau, who suggested the use of the condenser in the Ruhmkorff coil, explains its action as follows: "As soon as the points of the interrupter are separated the two free electricities of the wire run into the plates of the condenser."

Faraday, Poggendorf, Hearder, Maxwell, Lord Rayleigh, and others, have given more or less divergent views of the action. As a sample of these various views, the following quotations will suffice: Gordon, Electricity and Magnetism, volume ii, page 44,—"When circuit is broken the extra current induced in the primary wire by breaking is in the same direction as the primary current, and therefore tends to prolong the magnetization of the core. When a condenser is used the extra current spends itself in charging it. The condenser instantly discharging itself sends a current in the reverse direction around the core and at once demagnetizes it." S. P. Thompson, Electricity and Magnetism, page 365,—"The object of the condenser is, firstly, to make the break in circuit more sudden by preventing the spark of the extra current from leaping across the interrupter, and secondly, to store up the electricity of this self-induced current in order that when circuit is again made the current shall attain its full strength gradually instead of suddenly, thereby causing the inductive action of the secondary circuit, at make, to be comparatively feeble."

This latter explanation seems to require that the charge shall remain stored up in the condenser until contact is again made, while there is a path left open to it *via* the

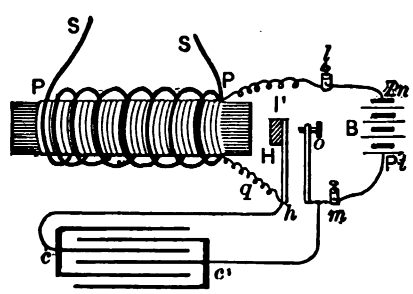


Fig. 11

battery and primary coil. See figure 11. The explanation quoted from Gordon seems to be the one most generally adopted, and it appears to be reasonably satisfactory.

This explanation may be given more fully as follows: Referring to figure 11, which is a diagram of the inductorium and condenser connections, HO are the hammer and anvil respectively, of the contact breaker, which is shown as open. The E. M. F. of extra current from the primary coil coincides in polarity with that of the battery B and both charge the condenser C. The extra current having exhausted itself, the charge in the condenser in excess of that due to the battery E. M. F. discharges through the battery and primary coil, demagnetizing the latter, and when the hammer again meets the anvil the remaining charge in the condenser is dissipated, leaving it again free to be acted upon by the combined E. M. F. of the battery and extra current.

The employment of the condenser to obviate sparking is of vast importance in printing telegraph systems, in which the currents are rapidly alternated by the reversing wheel or pole changer. Indeed without the condenser for this purpose the speed of transmission would be very materially reduced.

Another ingenious and useful application of the condenser, due to C. F. Varley, is that shown in figure 12. It was originally devised by Varley as a means of prolonging a signal which had been made by a momentary contact at the local contact points of the relay R. This the condenser C does by receiving a charge due to the difference of potential produced by the resistance of the recording instrument R′ at the moment of contact, and by discharging itself through the coil in the same direction as the current from the local battery B.

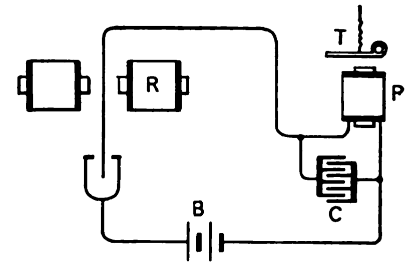


Fig. 12.

This principle is availed of also to advantage in the Delaney multiplex system of telegraphy in which the signals are made up of momentary contacts. It has also been used successfully in several automatic systems to prolong signals, and in quadruplex telegraphy for the same purpose.

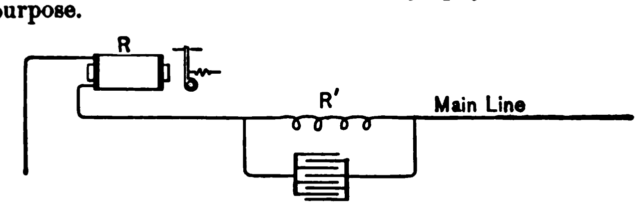


Fig. 13.

Another arrangement of the condenser (figure 13), is that in which its discharge is used in automatic telegraphy to reverse rapidly the magnetism of a relay, R. R′ is a plain resistance producing a difference of potential between the plates of the condenser. At the moment of reversal of the battery a portion of the discharging current at once reverses the relay R. A modification of this use of the condenser is also employed in quadruplex telegraphy to facilitate the reversals of magnetic polarity. The condenser has also been used in automatic telegraphy for the purpose of curtailing signals.

A very useful application of the condenser, which is also due to C. F. Varley, is that in which it serves as a repeater or translator of signals in simultaneous Morse telegraphy and telephony, in combination fire alarm telegraph and telephone systems and in simultaneous Morse telegraph systems using pulsatory currents, such as the Edison phonoplex, etc.

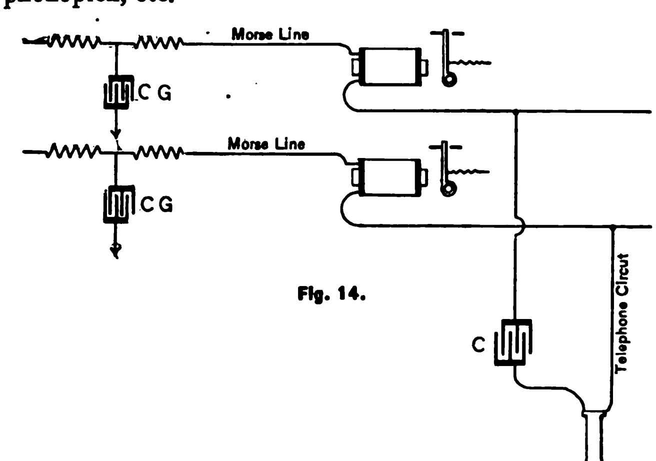


Fig. 14.

In these systems it not only acts as a translator of the signals but also prevents the grounding of the Morse circuits which would otherwise ensue, as when, for instance, a telephonic circuit is operated on a metallic circuit composed of two Morse telegraph wires, as shown in figure 14.

In certain methods of telegraphing to and from moving trains also, the condenser is indispensable. The same instrument is also of much value as a graduator of the telegraph currents in the Van Rysselberghe system of simultaneous telegraphy and telephony (C. G., figure 14). It has also been employed advantageously in this country as a means of preventing induction between parallel wires.

In the operation of long submarine cables the importance of the condenser is very great, and it is employed on such circuits in a number of different ways and for different purposes, as for example, to prevent the ill effects of earth currents, to avoid which, without the condenser or its equivalent, would necessitate the employment of looped cable circuits. In other words, the price of a duplicate cable for every existing long submarine line is virtually saved by the use of this simple instrument.

The most important and valuable application of the condenser, however, is probably to be found in its use as a static compensator in duplex and quadruplex telegraphy.

In the most successful systems of duplex telegraphy the home instruments are prevented from being sensibly affected by the home battery by means of certain arrangements of the apparatus (differential winding or the bridge method) and the employment of a so-called artificial line consisting generally of german-silver wire G, figure 15, which wire may be made to equal the main line in point of electrical resistance. This wire, however, has practically no electro-static capacity, and as this inequality of capacity between the main and artificial lines would tend to produce confusion of signals, the artificial line is given electro-static capacity, equal to that of the main line wire, by the attachment to it of a condenser or condensers in the manner indicated in figure 15.

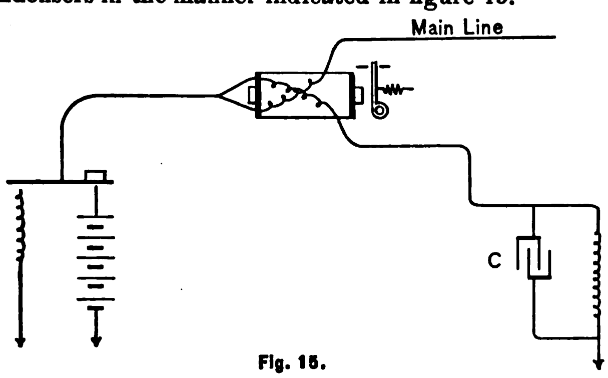


Fig. 15.

As previously stated, the Muirhead condenser used in long submarine cables is a nearer approach to the main line or cable in all respects than the usual condenser arrangement, but it is somewhat more expensive.

It is safe to assume that there is no substitute for the condenser as a "static compensator" in submarine cable duplex telegraphy, and no practically successful substitute for it in overland duplex telegraphy, and, further, it may be assumed that a large majority of the duplexed lines in this and other countries require a static compensator, and, therefore, the bulk of the duplexed circuits in operation would be practically inoperative without that instrument. On these assumptions the money value of the condenser as a static compensator may be estimated at millions of dollars.

The Baltimore and Ohio Telegraph Co. alone, by the use of this instrument, were enabled to operate many thousand miles of duplex and quadruplex circuits, which without it, could not have been successfully accomplished.

In electrical testing the condenser is also of great service, as in the measurement of electro-static capacity of cables; in the testing of joints; in measuring electromotive force; the internal resistance of batteries; insulation resistance by loss of charge; localizing breaks in insulated wire by capacity tests; in the nil method of testing resistances; and in measuring the resistances of batteries while working.

LIGHTNING ARRESTERS AND THE PHOTOGRAPHIC STUDY OF SELF-INDUCTION.[1]

BY E. G. ACHESON.

If in the opinion of any an apology is required—and it is thought that such will be the case—for thus presenting a subject that is in any of its parts a reproduction of the experimental work of such authorities as Professor Hughes, Professor Lodge, Dr. Hertz and others, the excuse is offered that the original motive for entering into the series of experiments referred to in this paper was a legitimate one, namely—the clearing away of a little fog surrounding some annoying phenomena attending the working of cables of electric conductors. The investigations became so interesting, so striking and suggestive, and some of the results appeared to have such a value, that it was believed they would afford sufficient excuse for this presentation.

While the measurements made during these investigations were not so accurate as it would be possible to obtain with more refined instruments, the probable errors were not so great as to make them wholly valueless, care in the readings and many determinations checking to a great extent the errors due to the crudeness of the apparatus. Appreciating the fact that untruthful results are less desirable than none, owing to their misleading effects, it is intended to impress the fact that the determinations contained in this paper can at best only serve as a possible guide for future work of a more complete and accurate character. It is also to be hoped that they may promote the already lively interest displayed by the scientific world in discharges, and the sometimes oscillatory character of electric currents.

The mass of material and composite character of the work to be presented will necessitate considerable care in selecting the order of presentation, and it is believed that the subject can be more easily followed if the thoughts and experiments succeed each other in the order in which they occurred to the experimenter, and this plan will be followed even when the after thought is of the greater importance.

As previously stated, the primary motive from which followed this series of experiments was the clearing up of some uncertainty as to the cause of a few annoying troubles in electric cables. But, to be more precise, it was desired to determine the cause of the occasional "grounding" and failure of cables used in telegraphic and telephonic service, when to all outward appearances they were perfect in construction, protected with lightning arresters, and immediately before the moment of grounding indicated high insulation resistances. A case of this kind presented itself for solution, in which there were some features of peculiar attraction to an investigator. It was a cable containing five wires about one mile in length, and of that design known as anti-induction, the cross-section being star shaped, each conductor having a surrounding wall of lead. It was used for telegraph work, and the conductors were connected at the ends to overhead lines, lightning arresters being provided for the protection of the cable; the terminals of the cable were on poles some twenty feet in height. The ground plates of the arresters were connected to the earth in the usual manner; that is, by wires running down the poles to plates in the ground.

This cable was continually getting into trouble, the conductors becoming solidly "grounded," and upon examination it was found that the "grounds" were caused by little kernels or spots of carbonized insulation. It was at the first moment thought that these had been introduced in the manufacture of the cable, but their repeated formation emphatically declared against this theory and made it imperative to learn the true cause. It was not probable that they were produced by the working currents, for they were of comparatively low electromotive forces, while the

1. Read before the American Institute of Electrical Engineers, at the College of the City of New York, Jan. 8, 1889.

presence of the lightning arresters would, in accordance with the prescribed rules of their action, render it wholly unlikely that they could have been produced by lightning.

A close study of the experiments of Professor Hughes on self-induction, and of Professor Lodge on the "alternative path" had produced an unsettled condition of my ideas as to the real value of a lightning arrester. The work of these investigators, together with some few experiments of my own, had produced a feeling of interest as to the efficiency of even the best arranged arresters as connected in ordinary practice. I was prepared to believe this to be a practical live case of a well-mounted and connected lightning arrester not protecting. It even seemed possible that the cable itself was, in reality, protecting the protector, when viewed in the light of Professor Lodge's "alternative path" experiment.

In order to come to some definite and practical conclusions as to the possibility of these troubles having been produced by lightning, a series of experiments was undertaken on lines somewhat analogous to those of Professor Lodge.

In figure 1, the general and important conditions of a cable placed in the earth and provided with lightning arresters as usually connected, are outlined. In the figure K represents the cable, L the line wire, and W the ground wire connecting the protector C to the ground plate G.

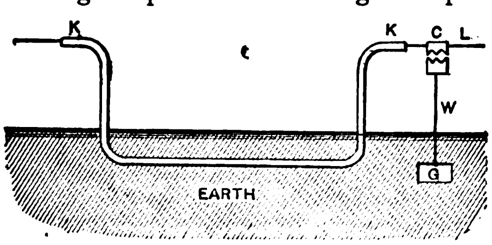


FIG. 1.

It is generally supposed that lightning—or an electrical discharge, as I prefer to call it—produced by the difference of potential between the cloud above the wire L, and the earth beneath, would, upon striking the wire, pass to the lightning arrester C, jump across the space separating the points to the wire W and thence to the earth, or the reverse, as the case may be. But while this is probably the case in many instances, it has not yet been satisfactorily demonstrated that there have not also been many cases where this plan of procedure was materially departed from, the discharge making a path for itself through the cable and the insulation, or perhaps dividing itself between both routes. In order to obtain more clearly defined ideas of

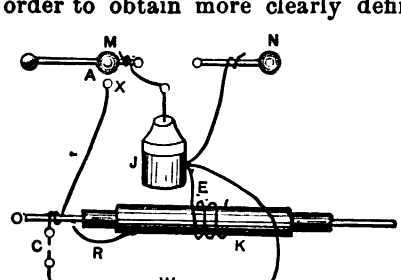


FIG. 2.

the action of a discharge under these conditions, the apparatus shown in figure 2 was used, in which it will be seen that the fundamental features and the connections of figure 1 are reproduced for experimental work, the cloud being represented by the inner coating of the Leyden jar J, and the earth by the outer one, the charge being produced by a Holtz machine, of which M and N are the conductors. The long length of the cable in figure 1 is replaced by a short one, K. As before, L represents the line wire, and in this case is connected directly to the conductor O in the cable. The lightning arrester, is replaced by an equivalent, C, composed of two points separated an appropriate distance. The wire W is, as before, the ground wire connecting C in the former case to the earth, and in the latter to its equivalent, the outside of the jar; the lead covering of K is also connected by means of a short wire to the same outer surface. While in figure 1 the point on the line L which is struck by lightning is subject more or less to accidental conditions, it is in the case of figure 2 selected and adjusted by the ball X, as is also the value of the energy of action, by the areas of the surfaces on the jar J and the length of the striking distance, A.

With the apparatus arranged as just described and illustrated, it was quickly determined that a discharge could with great ease be caused to pass through the insulation of the cable, even when the space C was but a fraction of the distance through the insulation, and the length of W a few inches of stout copper wire. The current of discharge seemed to divide itself, a portion passing by W producing a spark at C, and another portion passing through the cable. A few more experiments also demonstrated that

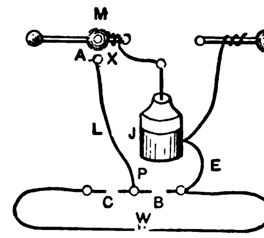


FIG. 3.

the wire W had apparently as much influence on the results as the space C, and consequently it became necessary to analyze the combination more completely to determine the relative values of C and W. With this object in view, the cable K was thrown out of the combination, and the connections simplified to those shown in figure 3. On close examination they will be found to be in every way similar to those in figure 2, with the exception of the replacing of the insulation of the cable K with a clear air-space B, and instead of connecting L to the conductor O it is here connected to a post P. The spaces C and B were both adjustable to a fairly accurate degree, B being easily readable to thousandths of an inch.

The system of experimentation was to take a certain length of wire, W, adjust A and C to known values, and then adjust B so that one spark would occur there for about every ten at A, and after having noted the length of the spark B a few inches would be cut off from W and B readjusted and again noted; this being repeated until W was wholly consumed. The values of B for these various lengths of W and a known length of C having been obtained, a wire similar to the original W was substituted for the former, and C having been removed from the circuit, as shown in figure 4, a similar set of tests were made, and the

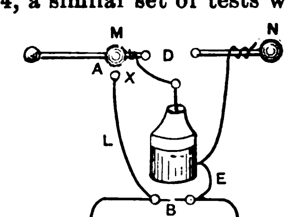


FIG. 4.

differences between the results, with and without C, indicated the true values of C and W in the combination, while the results with W alone show the value of each additional inch.

In plate A the results of these measurements have been plotted into curves. The length of W in inches is plotted horizontally while B in thousandths of an inch is laid out vertically. The capacity of the jar J was .0025 M. F., and A was retained uniformly at .286 of an inch. The full line curve is that of W without C in the circuit, while the

dotted one is that obtained with it in. The length of C was .02 of an inch. W for both tests was composed of a copper wire having a diameter of .052 of an inch.

A brief study of these curves teaches that, when W is but a few inches in length, C plays a very important part in determining the length of B, and also that its influence rapidly vanishes as W is lengthened, and actually produces an opposite effect after a certain length of W has been arrived at. Thus, with W 20 inches long, C has a value equal to 59 per cent. of the total circuit, at 110 inches it appears to have no value, while at 180 inches the value of the compound circuit is about 7 per cent. less than W alone. These

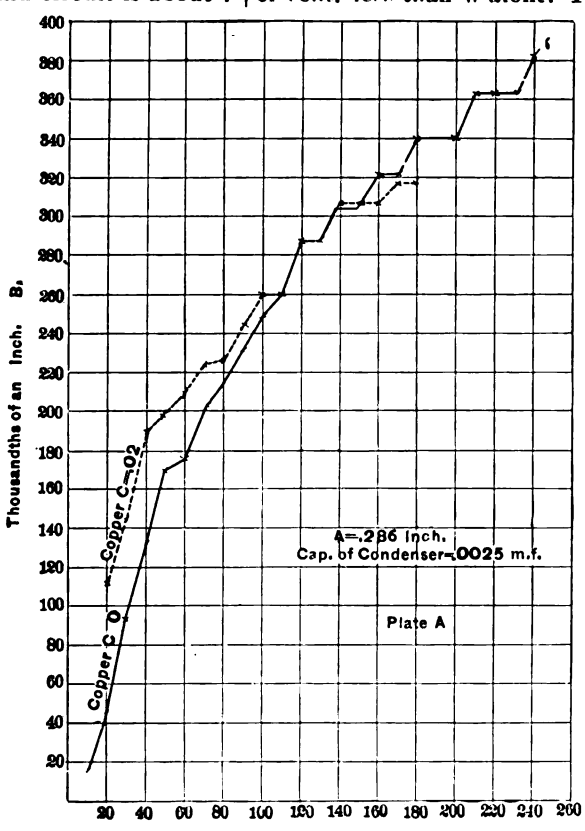


PLATE A.

points are, however, of even less importance than the lesson to be learned from the study of the curve of the results obtained with W alone. Here is a case where a relatively small amount of energy contained on the surfaces of the jar J will, when discharged into the circuit composed of the air space A and the wires L, W and E cause the passage of energy in the form of a spark at the point B of a length of over one-third of an inch, and this when the wire W is but 20 feet in length, or that of an ordinary ground wire down a telegraph pole.

This does not look very encouraging for lightning arresters with long ground connections, and rather puts to ridicule the fine adjustment of the points of these devices. The subject will, however, stand more than a little study and investigation before forming judgment, and perhaps the arrester is all right after all, in so far as the close adjustment is concerned, even if the long ground connection does have to go.

Those who are familiar with the recent investigations of Professor Lodge, investigations so exceedingly interesting and now so celebrated that few there are who have not made themselves familiar with them, will at once have recognized in figure 4 connections very similar to those used in the experiment of the "alternative path," by Professor Lodge. The results obtained by him and in the present experiments are in the main the same, and those differences that do exist are probably to be attributed to the following facts: Professor Lodge's work was done with instruments of great precision, the sparks were always produced between balls or rounded surfaces, and the object was to determine laws and formulate their mathematical expressions; while, on the other hand, the experiments now being described were made in some cases under the most difficult conditions, with apparatus limited to a most exceptional degree both in quality and quantity, a certain portion of the sparks were produced between points, and the object in view was to dissect, analyze and subjugate the phenomena under examination to and for the benefit of practical work, the every day affairs of the electrical profession.

It is, however, exceedingly difficult to avoid a little speculation, now and then, as the subject unfolds itself, and it is hoped the experimenter may be pardoned for any references that may be made to the theories that have been the immediate cause of some of his researches. It is even hoped that the work performed may atone for the views about to be advanced, notwithstanding the fact that they are quite contrary to those deduced by so high an authority as Professor Lodge.

After a considerable portion of this work had been done and the conclusions more or less formulated, I was much pleased and greatly strengthened in the opinions then being formed to learn through a letter from Professor Hughes to Professor Lodge, published in the London *Electrician*, issue of Sept. 28, 1888, that Professor Hughes had, at least formerly, held the same views of the "alternative path" that I had formed, and which will now be presented in connection with what is thought to be experimental demonstration of their truthfulness.

Referring to figure 4, it will be seen, as has already been stated, the conditions and arrangements of W and B are such as to produce and actually constitute the "alternative path," as shown by Professor Lodge. The simple assertion that they are alternative paths does not, however, make them such, and, while they may under certain conditions and adjustments become so, it is possible to conceive of their being otherwise. It is not beyond the bounds of reason to assume that the energy that has been discharged from the jar J, traversing the wire W, produces in it a condition that may be termed *electrification;* and on the disappearance of the controlling influence of this energy, would not the wire W return with an almost infinite rapidity to its original non-electrified condition, and, in doing so, produce as the result of this enormous rapidity of motion, an electromotive force at its terminals of a greater value than that of the original energy? In other words, will there not be a restoration of the energy expended in distorting the lines of energy within the wire, and this restoration being performed in a shorter interval of time than that occupied in its production, will not a higher electromotive force be obtained even though the value of the return would be less than that of the original, to an extent equal to the losses due to the internal friction of the mass?

This being the case, this current of discharge from the wire,—which was first discovered by Henry and investigated by Faraday and called by him the *extra current*—would, owing to its greater electromotive force, jump the space B and thus close its circuit, even when the distance was such as to prohibit the passage of the original current as discharged from the jar J.

It seems as though this might be the case, and, if it is, then the discharge that was obtained through the insulation of the cable in figure 2 need not have been a part of the original current from the jar J, but the current discharged from the wire W. If it was, a shortening of W would tend towards overcoming the difficulty. To test the case a short wire R was attached to the lead and bent out over the insulation so as to present a point to the conductor O, the distance between the point and the conductor being about the same as the thickness of the insulation; W was now removed, as was also C. It will be seen that E, the lead of the cable K, the short wire R and the space separating its end from the conductor O, form an equivalent to W

and C. With this arrangement it was not possible to cause a discharge to pass through the insulation.

Now, in accordance with the views which have seemed to me most probably true, this change is due to the reducing of the length of the path W, and which is now composed of R, E and the lead of the cable, this reduction resulting in a subsequent lowering of the potential of the extra or self-induced current. But if the theory of Professor Lodge's "alternative path" is correct, then the change would be due to a removal from the path W of a certain amount of resistance, which has been termed by Mr. Oliver Heaviside, *impedance*.

We here have an apt illustration of inertia under the American and English definitions, as so forcibly stated by Professor Ayrton. As I have presented it, the spark B is the result of inertia, with the American definition—a resistance to stopping. While Professor Lodge's theory would account for it by inertia with the English interpretation of that word—a resistance to motion.

Accepting the belief that the spark B, when adjusted to the critical point, was caused by the self-induction of the wire W, a variety of experiments were made with the desire of obtaining experimental proof of the theory. Repeated occasions presented themselves for mathematical work, and if time and attention could have been given in that direction, the results would unquestionably have been of interest and value, but the work was perforce restricted to the more limited confines of experiment and reasoning. The first experiment of the series was to replace the wire W in figure 4 with one of smaller diameter, and re-determine the value of B in the manner already used for a copper wire having a diameter of .052 of an inch, and of which the results have been plotted in plate A.

Before presenting the experimental results, it is desirable to consider what might be expected from these changed conditions. There will in all cases be practically the same amount of energy discharged into the circuit, for the areas of the condensing surfaces on the jar J remain constant, the length of the striking distance A also remains uniform, and while it is true that the resistance of W, as measured by a Wheatstone bridge, would vary inversely as the square of the diameter, the resistance of the complete circuit of discharge is, owing to the air space A, practically infinite, and hence the relatively trifling resistance of W, even when of the finest wire, may be wholly neglected.

The theory that the self-induced or extra current in a wire is a recoil action, is based primarily upon the hypothesis that there exists, before the electrifying current is discharged into the circuit, a prior state—the *electro-tonic* state of Faraday. This *electro-tonic* condition consists in the existence of lines of energy—thermal they may be—with directions coinciding with the radii of the wire; these lines or axes of energy being surrounded by circular lines of magnetic force. An electrical current being discharged through such a wire would cause, under the influence of its well-known magnetic whirls or circles, whose planes are at right angles to the line of propagation and in this case to the axis of the wire, a deflection of the planes bounded by the closed lines of magnetic force surrounding the radial lines of energy which are within the wire. The work of producing this deflection would, I think, constitute what is known as the variable resistance which meets a sudden discharge, and which was made the subject of that grand paper on "Self-Induction" by Professor Hughes before the Society of Telegraph Engineers, at their meeting of Jan. 28, 1886. This deflecting of the radial lines of energy, while constituting a resistance to the inducing current, is also, the source of, or rather, during the act of deflecting, produces, an electromotive force contrary to that of the inducing current. This counter electromotive force exists only during the interval of deflection, and quickly vanishes from the path of the inducing current. On the moment of the interruption of the inducing current, and consequent withdrawal of its attending magnetic whirls or circles, the deflected radial lines of energy swing back to their radial positions, producing by their motion an electromotive force of such a direction as to form a current in the same direction as that of the inducing current. This return swing or recoil, as of a spring suddenly released, is of such a velocity, and overlapping, probably, what might be likened to the tail end of the disappearing inducing current, produces a momentary electromotive force of a value higher than that of the original current. These being the actions of the forces and energies, it now becomes necessary to understand what differences, if any,

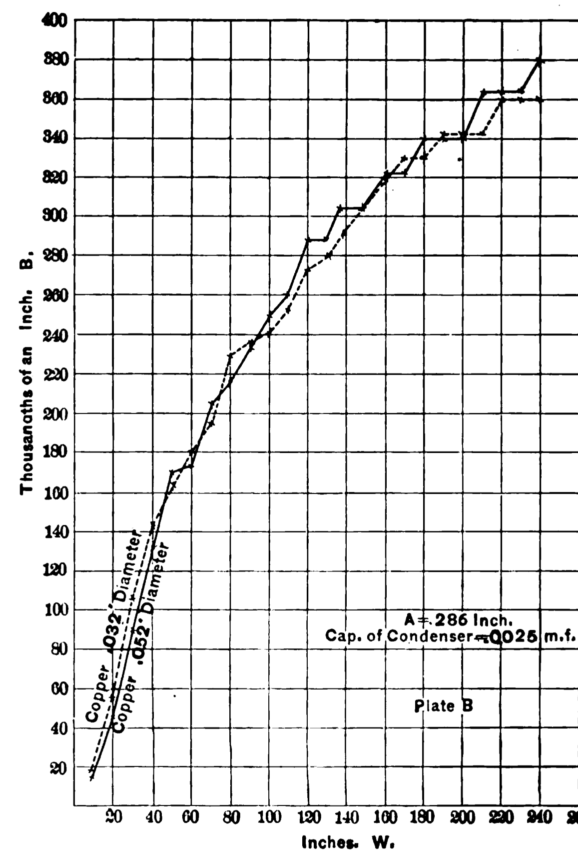


PLATE B.

the size of the wire through which the original current is discharged will have upon the value of the induced, or, as it is more generally termed, the self-induced electromotive force. All of the experiments and considerations will be made under the conditions of a constant capacity for the jar J and uniform length of A, and consequently one value for the energy discharged into the circuit. In all cases there will, of course, be a certain amount of the energy that has been discharged into the wire lost and converted into heat. This lost energy will be greater in value in the smaller wire than in the larger in a proportion inversely as their diameters. This greater loss in the small wire and resulting reduction in the available inducing energy would, of course, tend to produce a diminution of the self-induced current. This reduction is, however, exactly offset by the greater concentration of the inducing energy, its inducing value having been increased in a proportion inversely as the diameters of the wires.

It is feared this argument has become tiresome, and an immediate relief will be found in plate B, where I have plotted two curves; one, the full line curve, is the same as that shown in plate A, and was produced as formerly stated. The dotted line curve was made with a wire of copper having a diameter of .032 of an inch. The two curves are so nearly alike as to permit of the belief that they are in reality the same, and that the slight differences existing are due to errors of measurement. Here is experi-

mental proof that the electromotive force of the self-induced current, as measured by the spark B, remains constant as long as the energy discharged into the circuit is of uniform value, and is wholly independent of the diameter of the wire, and this seems to give countenance to the argument immediately preceding.

It is more than probable that those who have been following the subject closely will, before this time, have had the question asked, from somewhere within: "How would these curves on plate B have looked had one been made with an iron wire?" The answer is ready at hand on plate C. It is not exactly an answer to the question as stated, for there are here shown two curves, one produced with an iron wire and the other with a copper wire, but both are of the same diameter, .052 of an inch. The curve of the copper wire is the one you are already familiar with.

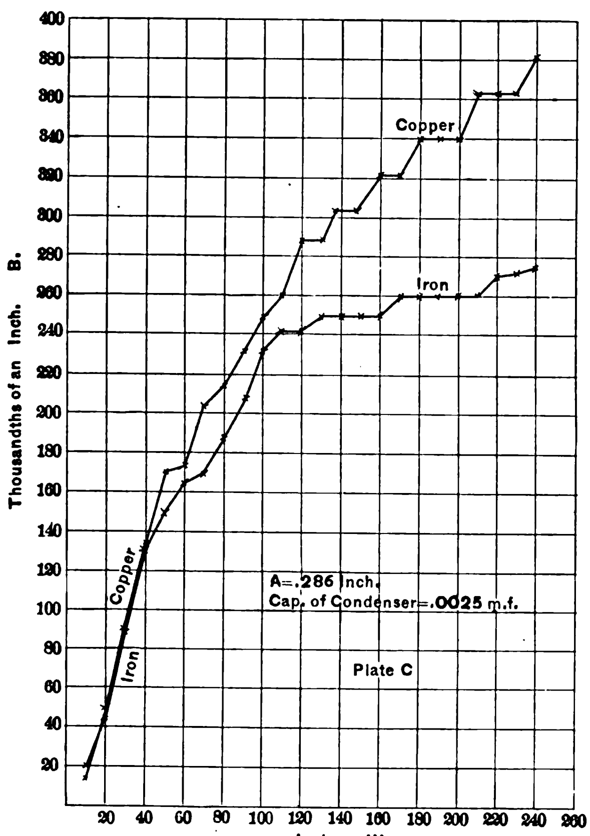


PLATE C.

This paper has even now attained to such proportions, and there are yet so many points to present, that nothing more than a moment's glance at these curves can be offered. A study of them teaches that for lengths of 40 inches, copper and iron will, when acted upon inductively by discharges of one value, furnish self-induced currents of like electromotive forces. From 40 to 110 inches they show slightly different values, while beyond this length their efficiencies rapidly diverge; that of the iron running much lower than that of the copper, and apparently fast approaching a maximum. As a means of accounting for these different efficiencies, I would suggest this theory. Up to 40 inches of length the time occupied by the passage of the discharged current was too short to permit of any magnetic effects occurring in the iron, and consequently the wire was equivalent to its neighbor, the copper; from 40 to 110 inches small magnetic effects were produced, resulting in a lag or retardation of the velocity of the recoil deflection of the radial lines of energy, and resulting, of course, in a lowering of the electromotive force of the self-induced current; beyond 110 inches, the time of discharge rapidly increased in duration, and thereby produced the decided flattening of the curve, as shown.

There is one more set of curves to present: They are shown in plate D, and were made with the object in view of determining the effect of a variation in the amount of energy discharged into the circuit. Experiments were made with both copper and iron wires; the curve of the copper is plotted in above that of the iron one. In the plate, the capacities of J in millionths of a microfarad are plotted horizontally, while the lengths of the B sparks in thousandths of an inch are plotted vertically. The length of the A spark was, as before, .286 of an inch. I was prepared

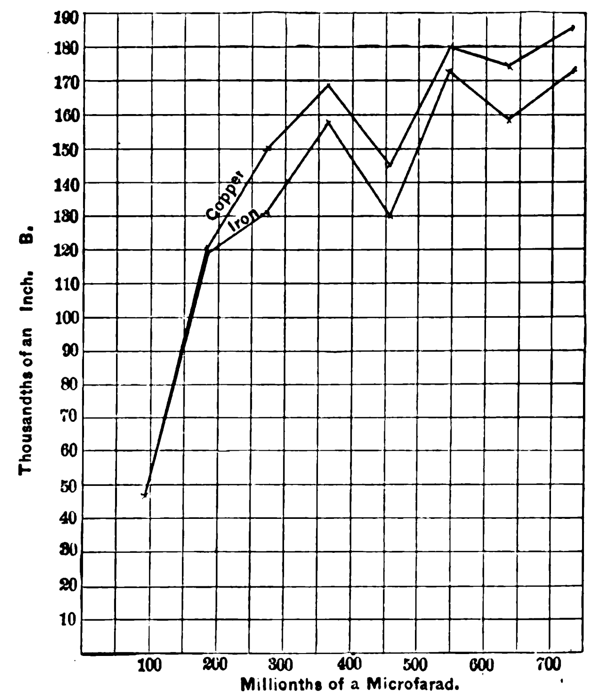


PLATE D.

to see the B spark increase as the energy discharged increased; but I was wholly unprepared to have it decrease as the result of added energy after a certain point had been arrived at, and still less prepared to obtain the wavy curves, as shown.

Time will not permit of entering into any consideration of the peculiarities of these curves.

There is a little experiment, the record of which I wish to interline at this point; it may answer a question, and perchance wet the powder of some intending questioner. Looking over my sketches and coming to figure 3, the thought struck me that an error might have been introduced into the experiment where the C spark formed a part of Professor Lodge's "alternative path," due to there being no connection having other than an infinite resistance between the ball X and the outer coating of J, while in all of the other experiments there was the circuit formed by W. It seemed possible that this change might have produced a different value for the energy of the discharged current, as the difference of potential between M and X might be altered. To decide the question, the connections as shown in figure 4 were used. The balls forming the terminals of the Holtz machine were caused to approach each other until the discharges occurred about an equal number of times between them at D and at A. Next the space B was adjusted to the critical length. If the existence or non-existence of the wire W and resulting metallic connection between X and J influenced the value of the potential of discharge, its removal ought to lower the potential difference between M and X, and cause all of the discharges to occur at D. The experiment, however, did not prove this to be true, the removal or replacement of W having no apparent effect upon the number of the discharges that occurred at A and D; but, of course, when it was removed every spark at A caused one at B.

A few experiments were now made to determine the effect various portions and positions of the parts of the wire W would have upon other portions of itself. The connections shown in figure 4 were used. A length of 50 inches of cotton-covered copper wire, with a diameter of .033 of an inch was used for the wire W. It was arranged in the form of a circle. A was, as before, .286 of an inch, and the capacity of J was .0025 M. F. The critical point of B was found for these conditions, and W was then formed into a figure whose two sides were parallel, and B was measured for various distances between the two sides. These distances were, however, only approximate.

Position of W.		B in inches.
Circle		.182
Sides separated	3¼ inches	.170
	2½ inches	.137
	2 inches	.137
	1½ inches	.137
	1 inch	.137
	½ inch	.114
	⅛ inch	.050

The next experiment, illustrated in figure 5, was to take the same wire, W, and coil it upon a paper tube having a diameter of ¼ of an inch, the wire forming a spiral of one layer about two inches in length. This spiral being placed in the position W the critical point of B was found to be

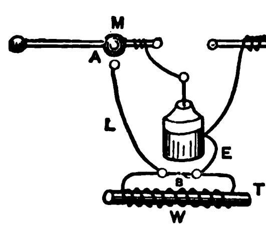


FIG. 5.

.197 of an inch, or over 8 per cent. greater than when the wire was in a circle. While the spiral was in the last position an iron wire one-tenth of an inch in diameter was inserted into the paper tube, and now the spark B only measured .170 of an inch, over 13 per cent. less than without the iron wire, and more than 6 per cent. less than the plain circle. Another experiment was made like the last, with the exception that the iron wire was long and bent around into a closed circuit, but it did not alter the results. The lowering of the value of the self-induced current upon the introduction of the iron wire was to me at the time startling, but a consideration of the case showed that it should be so, for a portion of the energy of the inducing current was absorbed in producing work in this mass of iron, and of a necessity weakened the self-induced current to an extent measured by the work this extracted energy could and would have done in the wire W had it not been withdrawn. I have, however, here a confession to make. I was all of the time considering that this energy was expended in producing magnetic effects in the iron wire until a friend who had called to see some of the experiments suggested that I insert a copper wire instead of the iron one. I did so. The effect was the same as that obtained with the iron wire. The explanation was simple: It was that not magnetic effects, but electric currents, closed upon themselves within the wire had been produced. The reduction of the length of the spark B now became a simple question of causing the inducing current to do more or less work external to the wire W, and as another means of causing it to do so, the spiral was surrounded by another spiral of wire, with the ends so arranged that they could be connected or opened as wished. With this arrangement, the spark B could be made to come and go, as desired: for by adjusting it to the critical point with the terminals of the outer spiral open, it would entirely disappear when they were united, all of which agrees perfectly with the former experiments and conclusions.

Another short series of experiments was conducted with parallel circuits, as shown in figure 6. The lengths of the parallel portions were 35 inches, the distance separating them being .052 of an inch. The total lengths of L and W were 130 inches. A and J were of the same values as heretofore used.

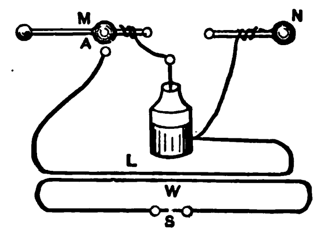


FIG. 6.

The conditions of the tests and the resulting lengths of the spark S may be briefly stated thus :—

Test No. 1..	L was	copper,	diameter .052 in.		S — .031 in.
	W "	"	"	"	
Test No. 2..	L "	"	"	"	S — .024 in.
	W "	iron,	"	"	
Test No. 3..	L "	"	"	"	S — .020 in.
	W "	"	"	"	
Test No. 4..	L "	"	"	"	S — .025 in.
	W "	copper,	"	"	

If my memory serves me right these results are the same, qualitatively, as those obtained by Professor Hughes, and clearly show the apparent sluggish action of iron, both in imparting and receiving magnetic inductive effects. Its relations to these magnetic effects resemble the actions of a polished metal surface when associated with heat; it radiates and absorbs poorly.

It now becomes my pleasant duty to present the concluding and, at the same time, most interesting and convincing proofs that W is not an "alternative path," but that the spark B is produced by, and consists of, the discharge of the self-induced current. I have called this series of experiments

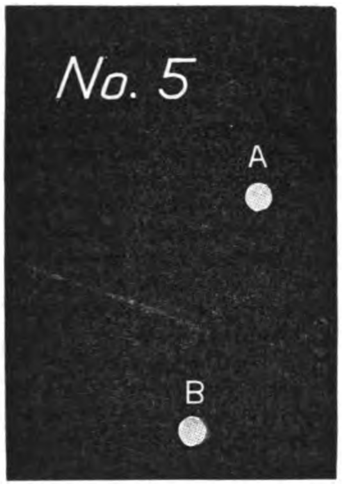
THE PHOTOGRAPHIC STUDY OF SELF-INDUCTION.

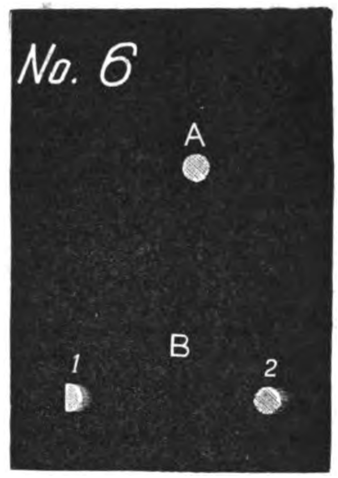
Unfortunately, at a late day, a day so late as to prevent my repairing the loss, I met with at least two accidents, and each of them cost me one or more negatives which were a part of the record of these experiments. I shall, however, endeavor to make those remaining demonstrate the desired points.

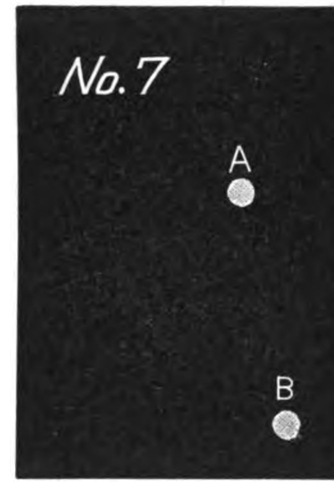
In making these experiments the end in view was to obtain photographic records of the duration of the spark A, with and without the spark B; with and without the wire W; with various lengths of the wire W, and, if possible, to detect a difference of time between A and B. A disc of tin plate, 20 inches in diameter, was mounted on an arbor and belted to a system of pulleys of such sizes that by working the train by hand a velocity of about 75,000 inches per minute could be given to a circle of holes that had been punched in the disc at a distance of one inch from its edge. These holes were about one-eighth of an inch in diameter and one inch apart from centre to centre. The disc was so placed in relation to the positions of the A and B sparks that a line stretched from A to one of the holes in the upper edge of the disc would pass through B. Immediately back of this same hole a sensitive plate was fixed so that the hole was in front of the centre line, while the plate was removed sufficiently far to avoid being touched by the disc. One-half of the sensitive plate projected above the edge of the disc; this upper portion was covered with a tin plate in which a hole was punched of a size similar to those in the disc. The lower portion of the sensitive plate—that is the part back of the disc—was also covered with a tin plate in which a window had been cut a little over one inch square, and in such a position that the holes in the disc passed in front of it. It will be understood from this description, that

while the disc revolved there could be two holes in front of the window, while there could not be less than one. With these adjustments sparks at A and B, separately or united, would produce an impression upon the sensitive plate, through the upper hole, and through one or two holes, as the case might be, in the revolving disc.

The B spark was adjusted to a point near the critical state, but, owing to the necessity of its production with the first A spark, it could not be set to the same delicacy of action as heretofore. The photograph shows a slightly blurred or indistinct outline on the right-hand side of the spot B, which is more clearly brought out by comparison







As a result of the accidents above referred to, it will be necessary to introduce the series of experiments with photograph No. 5, where we have the spot produced through the hole in the upper stationary screen marked A, and a spot lower down on the plate marked B, and which was produced through one of the holes in the revolving disc. The object in having the spot A was that it might offer a means of comparison between impressions made through stationary and moving apertures, and also show the effect of vibrations, if any existed, in the various parts of the apparatus. The value of the energy discharged through the circuit from J was disregarded, care, however, being taken that there should be no change in it throughout the entire series of experiments. The velocity of the apertures or holes in the disc was fairly, but not absolutely, determined to be 75,000 inches per minute. With this velocity of movement, a displacement of the apertures of one thousandth of an inch would represent an interval of time equal to $\frac{1}{75000000}$ part of a minute.

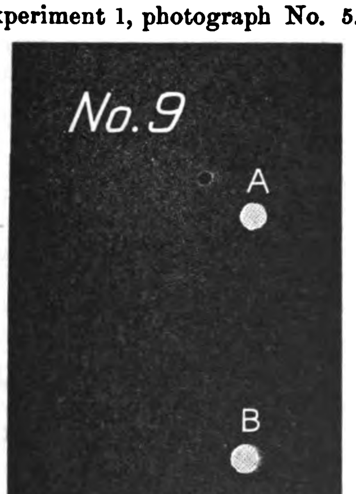
The series of experiments will be divided into four sets as follows:

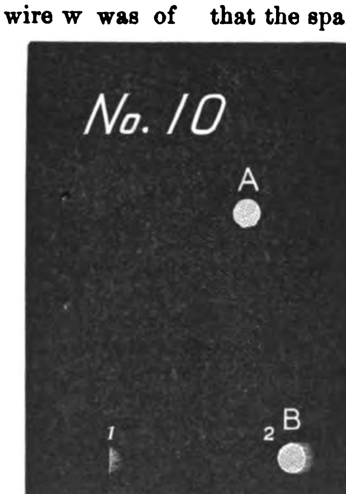
Experiment 1, photograph No. 5.—The wire W was of copper, 76 feet long and .052 of an inch in diameter, the spark A was $\frac{5}{16}$ of an inch and was retained at this for the entire series.

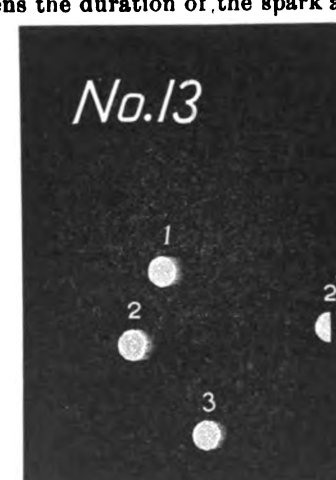
with the spot A. From this it is concluded that a measurable length of time was occupied by the spark, as the aperture in the disc through which this B spot was produced must have moved an appreciable distance in order to have produced this elongation or "ghost," as the photographic profession would term it. Owing, however, to the absence of any displacement of the distinct outlines of the spot, it cannot be assumed that there was any difference in the time of A and B, or, at least, not of sufficient value to permit of measurement with this apparatus.

Photograph No. 6.—In producing this photograph all of the conditions remained the same as those used in photograph No. 5 with the one exception of the spark B, which was removed from the circuit by separating the points beyond the striking distance. Here by chance two holes, or rather one and a half, were in front of the window at the moment of sparking, and produced the spots one and two. These spots exhibit displacements that, roughly measured on the negative, are one-tenth of an inch in length, and show a duration of the spark of not less than $\frac{1}{750000}$ of a minute.

From these two photographs the conclusion is drawn that the spark B shortens the duration of the spark at A.







Experiment No. 2, photograph No. 7.—The conditions of the circuit in this case were: Wire W shortened to 20 inches in length; spark B still out of circuit. This photo

graph shows about the same length, but a darker "ghost" following the spot B than did photograph No. 6, and indicates a corresponding increase in the *work done at* A.

Photograph No. 8.—The conditions are the same as the last, excepting that the B spark is again introduced. While there is still a measurable duration to the spark, the shortening of the interval due to the spark B is very decided.

Experiment No. 3, photograph No. 9.—In this experiment the entire apparatus associated with the spark B was cut out and the outer surface of the jar J was connected by a short copper wire to the ball X (refer to figure 4). An examination of the photograph indicates that A existed for an interval of time approximately equal to that of the last experiment (photograph No. 8) and very much less than that shown in photographs Nos. 6 and 7.

Photograph No. 10.—In this case the wire W was removed and the spark B adjusted to about $\frac{5}{16}$ of an inch. There seems to be, possibly a very slight increase in the time over that of photograph No. 9.

Experiment No. 4, photograph No. 13.—To this photograph special attention is invited. The conditions under which the negative was produced were wholly different from the foregoing. The tin plate covering the upper half of the sensitive plate, and which carried the aperture through which the spots A were made was removed, the plate was lowered, so that a point represented by the spot marked 1 came on a line with the apertures in the disc. The wire W was composed of 50 inches of cotton-covered wire like that used in some of the earlier experiments, and was formed into a circle. The B spark was removed and was not used during this set of experiments. The A spark was, as before, $\frac{5}{16}$ of an inch, and the spot 1 in the photograph is its impression through an aperture of the disc, and, as readily seen, shows a very considerable duration of time.

The sensitive plate was now elevated a little, the wire W was coiled into a spiral, as described in a former experiment, and the spark A was once more caused to pass. Spots 2 and 2′ are the impressions produced by it, and, as will be seen by close inspection, exhibit longer "ghosts," and consequently a greater interval of time, than was shown in spot 1. Once more the sensitive plate was moved upwards, and an iron core having been inserted into the paper tube upon which W was coiled, the spot 3 was produced by another spark, the "ghost" produced being smaller than either of the former ones. These three experiments show conclusively that the presence of the wire W in the form of a loop or circle in the path of the discharged energy, tended to prolong the action upon the sensitive plate; next, that the coiling of the wire into a spiral increased the duration of that action, and lastly, that the introduction of the metallic core into the coil, and consequent stealing away of a portion of the discharged energy, shortened the time of action to an interval less than that of the loop.

The field opened up by these photographs for theorizing and speculating is a very broad and rich one, but the time is now too short to more than indicate the manner in which these results add strength to the conclusions deducted from the former experiments. Applying to the photographic experiments the theory already advanced, that the B spark was a discharge from the wire W, it is found, as would be expected, that when B is absent the self-induced current discharges into the jar J, producing in its passage a spark at A; this spark following immediately upon the heels of the original A spark. The jar being in this manner recharged, but, of course, in the opposite direction and of a slightly lower potential, will again discharge into the circuit—the discharge at a reduced potential being facilitated by the thermal and, possibly, magnetic conditions of the air space A, and which were produced by the first spark.

This second discharge will leave the jar J once more charged, and will be followed by other discharges of a continually decreasing value, until the energy has been dissipated as heat or into other forms of energy through and by the various portions of the circuit. This subject of the oscillating discharge has lately received, at the hands of Dr. Hertz, a masterly and most highly interesting treatment.

Referring once more to photograph No. 6, which was produced by an A spark with W, composed of a copper wire 76 feet in length, the impression produced by the original, or first spark, is clearly defined, while in its wake is traced the track left by the sparks produced by the rapidly weakening, oscillating, self-induced currents—a track fading away like the tail of a comet, to an invisible end.

The next step in the inquiry is to determine the effect of introducing the spark B, and for this purpose reference will be made to photograph No. 5. Here we find, as would be expected, that the comet-like tail has almost disappeared, the natural result of having offered the self-induced currents from the wire W, a means of short-circuiting themselves across the points at B. The slight trace of a tail—a blurred outline—is to be attributed to the self-induced currents of the portions of the discharge circuit lying between the points of B and the surfaces of the jar J.

Shortening the wire W, with the spark B removed, should have the effect of increasing the amount of energy dissipated in the air space A, and further than this there should be little or no alteration. This increased amount of dissipation at A may be popularly explained thus: The total circuit into which the energy contained in J is discharged, and which consists of the space A, the wire W and the connecting wires, constitute the bodies or spaces from which the energy is radiated or dissipated, and, therefore, any contraction due to removing a portion of them will, of necessity throw more work upon the parts remaining. That this is correct is illustrated by photographs No. 6 and No. 7, where the conditions were the same other than a shortening of W from 76 inches in No. 6 to 20 inches in No. 7. A comparison shows that while the length of the "ghosts" are practically the same, that of No. 7 is heavier—more material. In the same manner in which the work was increased in the space A, so will it be increased in the wire connecting the points at B to the surfaces of the jar J, and for this reason the introduction of the spark B should not be expected to cut off the tail from the spot B to the same value obtained with a long wire at W. This is the case, as is shown in photograph No. 8, where W is 20 inches and B has been returned to the circuit. If the "ghost" shown in photograph No. 8 was due to the self-induced currents in the connecting wire, as has been assumed, then the same results should be obtained by cutting off the entire portion of the circuit represented by W and the apparatus associated with the B points, and short-circuiting these connecting wires. That this is the case is shown in photograph No. 9.

Cutting out W and replacing B did not seem to alter the results, very much, if any, from those last mentioned, and this is just what would be expected.

In photograph No. 13 it is demonstrated that the coiling of a wire into a spiral tends to cause a retension of the energy within itself, and is due probably to the gathering up of a portion of the energy radiated or dissipated by one convolution by the adjoining convolution, and thereby restoring it to its own mass. This retarding of the process of dissipation will result in a prolongation of the time of A and consequent action on the sensitive plate, as is shown by the increased length of the "ghost," following spots 2 and 2′ over that following the spot 1. As would be expected, the length of the "ghost" is immediately contracted upon increasing the rate of dissipation of the energy as results from the introduction of a metallic core in the coil of W, as is illustrated in spot 3.

The final conclusions to be drawn from these experiments are :—

1st. The "ground plate" of a lightning arrester should be connected to earth by as short a connection as may be possible.

2d. When an air line connects to a cable, a lightning arrester should be provided and attached to the armor of the cable by a connection not more than a few inches in length.

3d. When a short "ground wire" can not be used, one formed of a number of strands may be used, preferably not twisted into a cable.

4th. Any method by which a portion of the discharged current which passes over the "ground wire" may be withdrawn, will tend to increase the efficiency of the arrester.

5th. Under conditions similar to the tests, copper or iron may be used with equal efficiency, when the lengths are under forty inches, and over this length iron is more efficient than copper.

6th. The resistance of the "ground wire" is of little consequence, but it should have a size sufficient to carry off the charge without overheating.

7th. The insulation in a cable may be punctured by lightning, either by the direct discharge, due to the points of the arrester being too far apart, or by the current of self-induction from the "ground-wire," when that wire is of any considerable length.

8th. Dissipation of the energy of discharge reduces the self-induced current.

POINTERS.

.... IF the engine runs very slowly it is a comfortable thing for the man in charge; it is not so comfortable for the man who has to pay the coal bill.—*Gisbert Kapp.*

.... I WAS the original advocate of the plan of having the functions of the examiners [U. S. Patent Office] confined to examining records and citing similar inventions, leaving the applicant to determine whether or not he would take a patent in the face of the records submitted for his enlightenment, and I still believe that is the surest way of avoiding the abuses now existing. The work of the Patent Office has outgrown the present system.—*Edward S. Renwick.*

.... THERE should be no politics about the Patent Office, not even in the appointment of the commissioner, and then there would probably be a greater degree of fairness. This would also obviate the frequent change of commissioners. More room, more intelligence and less red-tape are also requisite to complete reform —*Edward C. Davidson.*

.... THE complaints that patent attorneys, inventors and others are justly entitled to make, arise mainly from the substitution of green, fresh young men for the men of longer experience.—*Charles J. Gooch.*

.... THE intention of the patent system is all right, if Congress would appropriate enough money to make it efficient. The Patent Office is much more than self-supporting, and inventors feel that some of the surplus should be expended to secure to themselves fair play and more expedition. The abuses complained of are largely due to parsimoniousness on the part of the government, as the salaries of examiners are so small that they seek more profitable fields of usefulness.—*Harrold Serrell.*

.... THE Patent Office needs more room, a larger force and less red-tape and incompetency. Too much time is wasted on unimportant technicalities, and the evil is growing.—*James A. Hovey.*

.... I AM sure the general intention of the Patent Office officials is to be fair and just to honest inventors, but many abuses have crept into the modes of conducting business in the department. The officials doubtless try to secure expert and honest examiners, and, as a rule, they succeed, but some incompetent men get in, and others undoubtedly lack honesty.—*Alfred E. Beach.*

.... THE first thing in a novelty is to make it perfect. When you have made it perfect, and you find it expensive, the next thing is to try and lop off the excresences, and bring it down to within the range of practice.—*W. H. Preece.*

.... ONE of the great desiderata of a system of lighting is constant supply. It is not sufficient to supply the illuminant for a specified number of hours per day; what the householder wishes to have is a means by which he has always at hand a reliable source of light, capable of supplying all his requirements night and day. —*Henry Edmunds.*

ADDRESS BEFORE THE ELECTRIC CLUB.

BY PROFESSOR C. F. BRACKETT.

[New York, December 20, 1888.]

CONDUCTORS—SPECIFIC RESISTANCE—A FORECAST IN ELECTRIC LIGHTING.

THIS is the first time in my life that I ever had the pleasure of facing an Electric Club, although it has been my fortune, good or otherwise, to give instruction in electricity, and I am bound here to confess—a very willing confession—that if I had students under such auspices as I should have had them here, I think I might have succeeded in teaching them something. The Electric Club of New York seem to know how to surround themselves with the physical inducements to study, and I think if students could generally be introduced into such pleasant circumstances they would be considerably more inclined to appreciate their opportunities than they are at present.

The topics to which I would invite your attention are those which present themselves naturally to the working electrician as well as to the student of electricity. Let us consider first a practical matter. In the applications of electricity to our daily wants we make use of those material substances called conductors, and we interpose them in the path where we would like electricity to flow, but where we do not wish it to do so we place substances called non-conductors. It is known to you all that there is no very sharp line of demarcation between these two kinds of bodies. It will suffice in general to say that the common commercial metals act very well as conductors. I desire to draw your attention to two points, and, for the purpose of illustration without a black-board, I will ask you to follow me with your imaginations. Suppose one point A, and another point B. They are at different electrical potentials. If we join the point A with the point B by means of some metallic conductor, we shall find that in a given time, very short, there will be no difference of potential between A and B, and we shall find also, if we use proper appliances, that something has been going on in the wire, or in the region of the wire, which connects those two points. When we say in the wire we are not sure that we are telling the truth; when we say *in the wire, or in the region about* the wire itself, we are sure. If we employ successively copper, gold, or silver wire, we shall find that the equalizing of the electrical conditions of points A and B is in general not accomplished with equal facility. In other words, we find that all bodies are not equally good conductors. Now, copper wire being generally used on account of its excellence as a conductor and its moderate cost, it interests the electrician to know when he has the most efficient variety of copper wire. The matter then which I wish to discuss with you first—and let me say in passing that if I do not make every point clear I invite questions as we go on—is, how is the electrician to know that he is using the very best quality of conductor under any given circumstances. Often times he wants to use the greatest possible power of conduction with the least possible bulk, or with the least possible amount of weight, as, for instance, in the construction of certain pieces of electrical apparatus, such as the dynamo. He will be guided in his constructions very much by his knowledge of the materials, and especially of the conductivity of the materials which he proposes to use. Let us speak for one moment of the specific conductivity of conductors. The word is used precisely as in science we use it, with reference to other properties of matter when we refer them to a standard. It was assumed by the committee of the British Association that *pure* metals should in some way be taken as the standards to which commercial samples should be referred. In the case of copper we must be able to secure it in a state of perfect purity, and to draw it into a wire of perfectly uniform diameter. A definite length and diameter will then fix

the standard. Or we may take a definite mass of copper, as determined by weighing, and fix the length of the conductor to be made from it and assume that nature will fix the diameter. Finally, we may attempt to deduce the diameter of a known length from its weight and specific gravity of copper. All these plans are beset with difficulties. Let us discuss the matter.

If we say that a wire one one-thousandth of an inch in diameter and one foot in length shall have a resistance of 9.718 ohms, we have made a statement equivalent to the one made by the British Association Committee. How can you know that this wire is a foot in length? That is not a very difficult matter. How are you to know that it is a thousandth of an inch in diameter? There comes a difficulty. But the British Association did not attempt to make a wire just one one-thousandth of an inch in diameter. On the contrary, they drew a wire of some size and deduced from the resistance of that wire what would be the resistance of the same metal if its diameter were reduced to one one-thousandth of an inch and its length were made one foot. Now, let us, before we leave this inquire what are the difficulties in the case. We have a wire which in general terms we will say is one-sixteenth of an inch—Matthiessen's. We want to know in tens of thousandths of an inch exactly how much it measures, for the least variation in the diameter of it of course implies a much larger variation in the area, and that implies a very large variation in the conductivity—so the slightest error made in the measurement of its diameter enters very largely into the final result. It is true that we have screw gauges and vernier calipers at our command; but yet we can hardly by any of the devices determine the real diameter to within at least fourteen or fifteen-hundred-thousandths of an inch, and that makes a vast difference in the conductivity of a wire, especially in the case of small wires. Let us take the other plan, specifying that the samples being a foot in length shall weigh so many grammes or grains; again we will have one of the British Association methods on the basis that a cubic foot of copper weighs 555 pounds—that it is nearly 555 pounds. If a cubic foot weighs about that and not exactly that, there is a doubt about it which will seriously affect the result. The difficulty is at once seen when stated. They also specified that the specific gravity is so and so, or that it shall be so and so. Now, if we take the Smithsonian tables collected under the direction of Professor Henry, we shall find that the specimens of copper there reported, as respects their specific gravity, vary all the way from about 8.95 down to 8.40, a variation enough to make a very great percentage of difference in the conductivity of copper. Now, to what are these discrepancies due? The question what is the specific gravity of a metal is the one which can only be determined in a given case by taking that particular piece of metal which is to be employed and determining its specific gravity. Then let us look at the process of wire-drawing. Suppose we draw the wire through the draw-plate. What is the operation that goes on? Is the wire simply stretched and made longer and smaller? Is the wire compressed as it passes through? The experience of the wire drawer will perhaps come to our aid and tell us something about it. I had occasion, some time ago, to apply to one of the most expert drawers in the great works at Trenton—Roebling's—using a jeweled draw-plate through which the wire was to be drawn, and having a finished sample of wire to be drawn through it. The workman at once said: "That cannot be drawn through it." Said I, "Why?" He said; "The wire is too small." Now there may be, and there probably are, gentlemen present who will see at once the reason of that statement. It is found that if we wish to reduce a wire from one size to another, we must reduce it by a considerable amount or we cannot draw it through a plate at all. The wire is a little large for the hole. Instead of there being pushed up a mass of the metal in front of the hole, the metal is compressed and becomes very hard, and is wedged into the plate, and breaks. If, on the contrary, the reduction in size is so great that this does not happen, it is found that it can be drawn through with moderate tractile force, and that it has a more uniform structure. Let us then consider what happens when we attempt to pull the wire through the plate; what happens to the wire after it is pulled through. Here experiment comes to our aid. Wertheim, in some experiments of his, found that when any substance is stretched, the entire bulk of that substance is enlarged. An instructive laboratory experiment is performed by means of a long mass of rubber in the form of a parallelopiped, whose length can be measured, whose side and thickness can be measured. When we stretch it we find that if it be calipered at uniform distances, and the volume under those circumstances be computed, it is greatly increased. One would naturally think that it would be diminished in section as much as it is elongated, so that its volume would remain constant; but it is not so. If you take a piece of rubber as long as your finger, find its specific gravity by weighing it in the usual way, put this in a stretching apparatus, and you will find its specific gravity has been diminished, and the bulk increased. The same thing is true of the copper. The wire after being compressed in its passage through the draw-plate is expanded by the traction required to draw it through; and, besides this, the structure of the metal is greatly influenced by the constant change in the relation of the surface and the central parts. The former is constantly held back, and furnishes the material from which the increased length is derived; it is thereby heated and so annealed while the interior remains comparatively hard and brittle, and so is liable to break and leave the interior of the finished wire unsound. Now, the question which arises here immediately is, how much it will be expanded, and, therefore, what will be its specific gravity after it is through? You must see that it will depend on how much it is reduced in size, and what is the condition as regards annealing before it is drawn through and afterwards, so that when you state that wire is hard drawn and has such and such a specific gravity, you are stating two things not necessarily compatible. If you have a certain mass of matter having a certain length between points A and B, if the mass be highly compressed so as to occupy only a small space, one might suppose that the particles are nearer together, and therefore they could less readily execute the motion involved in the transfer of electricity from one point to another. One might say on the other hand, if a wire were annealed, rendered larger, there would be greater freedom of motion, and so, a greater conducting power. Those are both theoretical matters, but there are experiments tending to prove the truth of either position. It is found that the conductivity is improved by annealing. But what do you mean by annealing? Do you mean the wire shall go into the oven and be heated to redness and kept so a certain length of time, and then be allowed to cool spontaneously?

A short time ago a specimen of wire came to my notice to be measured for conductivity. It was found to be very low. On examining its physical properties it was found that if it was flexed sharply on itself any attempt to straighten it broke it short off. The question was given to me for investigation, to find to what this was due. The conductivity being too low, and the physical state of it being such as we would call brittle, it was supposed, of course, that it might contain arsenic, or that it might contain sulphur, and very rigid tests were made for these substances, but neither of them was present. Tests were made for oxide of copper, which in the annealing process might have been absorbed into the interior. On making a careful test for sub-oxide of copper, there was found to be no more present in it than in other wires which were tough and whose percentage of conductivity was over a hundred. Then the question arose, to what is this due? Accordingly a sample of the tough wire that could be

flexed in any way you pleased, that had a percentage of conductivity of over a hundred, was taken and heated for a little time in the presence of hydrogen gas—heated to redness. It was found on cooling that it would not bear a single sharp flexure. On trying to make it bend as an ordinary wire, it would break half way off. It appears then, that by the pressure of hydrogen and the existence of a high temperature, a new molecular condition was impressed upon it. This investigation was made by Dr. McCay.

Along the same line I might note another experience which was accidentally come upon. A large amount of iron wire was made for telegraphic purposes. It was shipped to its destination, and on being unloaded roughly, as usual, the wire was found to break into pieces as if it had been a rod of glass. On being carried back to the factory and nothing else done to it except to draw it through the draw-plate, it was thoroughly restored, showing that the whole matter is due simply to molecular change—that it was restored by mechanical treatment.

Now this short discussion will settle the point which I have brought up—what did the British Association mean when they said a wire so long having such a diameter shall be taken as a standard? They mean absolutely nothing, for they have not specified how it is to be drawn through the plate; they have not specified how it is to be annealed nor how many times it is to be annealed, nor given any specific mechanical detail about it.

Now, let us consider another phase of wire drawing for a moment. Suppose we had a standard. Suppose these questions were all settled, first as to the purity of the material, second as to the method in which it should be drawn, and how it should be annealed, what kind of draw-plates shall you draw it through? If you are to use jewels, such as a topaz or something of that sort, for every final drawing of the wire, that course would seriously embarrass every concern in the community. You can draw only a very limited amount of wire through the plate, and then it is worn out. We must, therefore, fall back on steel, the only available thing, and see how that will work.

I will narrate a little experience. Having wires sent to me by various firms to study and report, I have invariably found that when a lot of wire which was continuous, without any joints, was examined, both ends of the wire were large and the middle small. I think that is probably the experience of all—that the middle is reduced. What, therefore, is the diameter of the wire?—how shall we get it? It is larger in one direction than in that at right angles to it, and gives you neither a circle, an ellipse, nor any other regular geometrical figure. Well, of course, those who wish to save trouble say, let us weigh it. Suppose we determine to measure it without weighing it. Of course we will have to run our calipers around the wire and we have to discuss the figures we shall get from that, and having determined the area of the cross-section and the length of the wire we can refer it to the standard of the British Association, and if that were accurate our work would be done.

But we find that it is not safe to assume that these wires will be uniformly smaller in the middle, and we have, therefore, to look into the facts. When we begin drawing the wire through the plate the first effect of it is to heat the plate. Before the heat is conducted to the outer parts of the plate the interior parts get warm, and they have no other way of expanding except inwards, thus contracting the hole. The consequence will be that, for a short time, the wire will pass through the hole at nearly its full diameter; but from the beginning the heat evolved in consequence of friction will cause the diameter of the hole to decrease until at length a point will be reached when the conduction and radiation from the plate will remove the heat as rapidly as it is produced. Meanwhile the rough surface of the wire will cut away the plate and thereby increase the diameter. There will thus be two stages in the alteration of the draw-plate; during the first the diameter will on the whole be diminishing, and during the second it will be increasing. Accordingly the wire will be smaller at some point between the extremities than at either of them.

The wire will then be of varying diameter, and one who would ascertain it for the purpose of finding the conductivity of the sample, will have to make a series of measurements at various points along the length as well as in various azimuths about its axis, very much as the surveyor treats an irregular piece of land. Suppose he wishes to avoid all this labor, and says, I will weigh it. There is difficulty if you do weigh it—how will you deduce the bulk from the weight without knowing the specific gravity? If you turn to tables you will find 20 or 30 different specific gravities assigned to copper wire. If you say, I will determine the specific gravity myself, then the expense will be too great if any considerable number of samples are to be tested.

Now, having stated some of the difficulties with reference to the matter, let us inquire what ought to be done. It is known, I suppose, to most of the gentlemen present, that the British Association Committee still have this matter in charge, and have undertaken, at their recent meeting at Bath, to have the whole question re-examined, and it is to be hoped that something will be elicited which will give us a standard for the conductivity of copper wire, so that we shall know whether we are getting one thing or another. It may surprise some of you to be told that we very frequently have from the manufacturers in this country samples which will run as high as 103 or 104 per cent. of conductivity. In other words, they are three or four per cent. better than they can be, taking the British Association as a standard. Now the matters which I have already brought forward, of course, enter into the reasons. At the outset it was assumed that the pure metals were to be accepted as standards. That is not the whole matter. It does not by any means follow that when you have assured the purity of a metal you have secured the highest conductivity. You have also to ask what is the length, what is the diameter, what were the methods of its preparation, and, unless they are all defined, there can be no certainty that you are getting within two or three, or three or four, per cent. of the proper conductivity.

Now some one says, what is the use of this after all? There are conditions in the art of the practical electrician in which he must say beforehand, precisely how many feet of wire he can employ, precisely how much space they must build up in order that he may have symmetry, equality and proper conducting power. I think any one who has attempted to wind the coils of the dynamo machine so as to secure a definite number of ampere turns will agree that a variation of two or three per cent. in the conductivity of his copper wire makes the difference between success and failure.

Now, having said so much with reference to a practical problem that interests everybody, let us turn our attention a few minutes to matters that are more speculative. It is not only true that it becomes important for us to have conductors which shall convey from one point to another the disturbances which we call electrical; it is also true that in the construction of machinery at the present time, we are to take into account the air spaces between those conductors; we have to take into account the intermediate thing which separates one conductor from another, and inquire what goes on in that space. And it will not astonish many present when I put it this way. Theoretical electricians who are studying the question very hard are getting to look at it in this way. We are not more concerned with what goes on *in* the conductor than we are with what goes on *about* the conductor. In other words, the principal transaction in the electrical transmission of energy from one place to another goes on not in the substance of the wire but in the space which surrounds the wire. We ought to get into the spirit of these electricians,

and look at the ether through which we move as the most important of all materials with which we have to deal. Think now of the air and of everything utterly vanished, a perfect vacuum, and then cut out a solid "chunk" of the vacuum and see how it behaves. We shall find, probably, in the light of recent investigations that this is the most important thing we have to deal with, that the whole action which we call transmitting goes on in that, and that the conducting wire is only a hole bored through it. It is simply so many masses of matter called molecules that are swinging around and making an easier path, and this determines the direction through which the electrical disturbance shall be manifested. There are certain transactions which we may look at. For instance, a wire can act inductively through a vacuum just as well as through the air. No one is, I think, able to imagine to himself, under any circumstances, whatever he may say, action across a space where nothing exists. Faraday in grappling with this same subject said, in substance, that it was unthinkable. Newton gave his great deliverance also along the same line.

If, then, action at a distance must be ruled out, there is something between the conductors themselves which we have to take into account. Now the experiments and researches to which your attention has been called in the electrical literature of the day, which have been going on for several years past—in fact they date back many years—have cast a great deal of light on this subject, and while it may not seem immediately practical, it may be that some word which will be dropped in what I shall say, or in the discussion, will set some one to thinking.

Now, in order to proceed step by step, let me propound the ultimate question which I suppose may interest a large number—how to produce an electric light in the very cheapest possible way? That is a practical question. Now I am going to try to see if we can get to it in a philosophical way (without realizing it), but upon the paths if possible by which it will probably be ultimately reached. Faraday, in one of his brilliant papers in which he set forth the principles of "the new electrical machine"—the starting point of modern dynamo appliances—made use of words like these :—

"I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction than of exalting the force of those already obtained ; being assured that the latter would find their full development hereafter."

Now, in the spirit of what Faraday said, let us look at this subject. Nothing will be practical that I shall say. I shall not show you how to make that machine, but I propose to scale past the lines along which it may come, and in doing so I will be very brief. First, what is light? This solid ether which we have spoken of, which is a necessity in the phenomena of light and which Fresnel assumed has an existence, in order to tie together the inevitable deductions from his equations, must be thought of as something evidently more solid than the solidest things we think we know about. When we get light we get it by setting up vibrations in the ether, and all I say about these vibrations is this : They are periodic, they are uniform, they are transverse to the line of progress, so that if the beam of light were going directly from me to you, the motion is athwart the beam, so that a particle can be thought of as moving this way and another around that way (illustrating with a pencil), and so in every possible direction at right angles to the line from me to you. Now the question is : Is there anything connected with electrical science by which we shall be able directly, ultimately, to evoke that method of movement? In 1832, Professor Henry showed that when a Leyden jar is discharged the spark which we have been perhaps accustomed to think of simply as a passage of electrical fluid from one side to another, on the contrary, was a series of transmissions back and forth from the outside to the inside. This he showed to his own satisfaction and embodied his conclusions in a paper which is, of course, extant at the present time. Later, Fedderson took up the question and studied it with care, and showed how to compute the length of time involved in any one of the elementary discharges passing back and forth. In 1855, Sir William Thomson showed how to compute from the induction of the wire and the capacity of the jar, the time interval involved in one of those oscillations. Here is a trough of water on one end of a pipe and another on the other end. The one trough being empty, water runs through and accumulates on one side and by its impetus it will pile up a little higher and we will have a series of oscillations, and finally it will come to rest. That is exactly what happens when a Leyden jar is discharged by a series of oscillations. Now we can put such a conductor between the two troughs that there shall be only a steady flow from one side to the other. We shall find that there will be no oscillation in that case back and forth. If we put there a very small wire or a wire having large inductive capacity, I can get a steady discharge in the case of the Leyden jar. Any way we can control it and show what is the length of time involved without any difficulty.

Now, to make a long story short, it may be stated that Hertz has for some time been studying the oscillatory discharge, and his more recent labors have thrown a great deal of light upon them. I will not allude to all of his experiments in order, but only mention such of them as best suit my purpose. In order to understand one of them, consider a simple experiment in acoustics. A long rod of wood or metal is held firmly between the thumb and finger at its middle point. If it be pulled gently with the other hand which has been covered with a little powdered rosin, the rod breaks out into a clear musical note, as clear as that of a violin. The effect of the friction has been to produce a series of condensations and rarefactions which travel along the rod, thus showing that it is in vibration. Hertz arranges a long wire with a metallic conductor of considerable capacity on each end. The wire is cut apart at the middle point, and the ends so made are brought in contact with the discharge rods of the induction coil, which are furnished with small balls between which the spark can pass. A small rectangle of wire with one side cut open at the middle, and the two ends armed with small adjustable balls, serves to show what is going on in the long wire system just described. This it can do by the presence or absence of a spark at the opening between the balls. When the induction coil is set in operation, the electrical oscillations in the primary system are shown by the induced sparks in the rectangular system. If the periods of oscillation in the two systems be made as nearly as possible the same, the brilliancy of the spark in the secondary is much increased—just what should happen on the principle of resonance. They are then waves set up in the conductor, and their frequency can be calculated. Now, according to the electro-magnetic theory of light proposed by Clerk-Maxwell, the disturbance which constitutes electrical induction should travel with the velocity of light, or about 185,000 miles per second. It is then easy to find the length of the oscillations with any given number of alternate discharges, such as are produced in the experiments of Hertz, for we have only to divide this distance, 185,000, by the number, which gives the length of one, provided we may assume that the disturbance is propagated in the wire with the same velocity as a disturbance is propagated in the air. Hertz, however, found that this is not the case. His experiment was carried out somewhat in this way : Two large metallic plates were furnished with wires terminating in knobs, and so placed as to be in the same vertical plane, with the knobs near each other, so that a spark could pass when the two were connected with the induction coil terminals. Behind one of the plates was placed a third, so as to be parallel to, and near it, and from this a wire was led to a

considerable distance away and put to earth. Any electrical disturbance in the plates joined with the induction coil would, of course, induce a corresponding one in the third plate, and so in the wire connected with it. Suppose we want to find out whether there is anything going on analogous to the transmission of waves in sound, we would go alongside of the wire and see if there is a place where there is a neutral segment, and further, if we find that repeated again and again, in other words, we ascertain if there is a series of waves—what kind of a test shall we employ for this purpose?

All we have to do is to make a little induction coil, put a knob on each end of the coil and bring them near each other, and see whether a spark passes. Suppose the wire be stretched here (illustrating with an imaginary wire), we look carefully and find a spark passes. Then passing along the spark grows dim, now it grows a little stronger; we find it here very strong; we pass right on and find that when we go over the same distance again it increases and diminishes. If we do this we find the distance between the nodal points. In other words, we find the result absolutely, the result we were looking for, by the inductive effects in the wire.

Now I will not weary you with that part of the thing, for there are a great number of experiments which can be tried. We find in this instance that when the wire transmits these electrical disturbances, there is in the ether, or in the air, close by its side, another disturbance transmitted; that is to say, we have the one taking effect along the wire and the other taking effect along the ether. Now do they travel with the same or with different velocities? It is found that the rate of transmission in the wire is different from the rate of the transmission in the ether. Hertz finds that if he employs iron wire, copper wire or zinc wire, or wire of any other metal, it makes not the slightest difference in the position of the nodal points. In other words the length of the wave remains unchanged, and it makes not the slightest difference whether the diameter be small or great.

Now, let us look at what light is for a moment, and then we will see how we should produce it. I have already stated that light is a motion transverse to the line of progress of the wave. Now I am going to ask you to follow me through a little severe thinking.

Faraday, in the height of his enthusiasm as an experimenter, endeavored to connect gravitation directly with electricity. He made coils of wire and threw them out of an upper story window and let them fall down to the earth in order to see if he could get any electric disturbance. Faraday had already investigated an action closely analogous to that of gravitation, for he more fully than any one else explained or rather described the character of the region about a wire which is conveying a current of electricity. Here is a wire and a current. Suppose a current is passing directly down through it. We need not discuss now what a current is, but will take it for granted that the wire joins the brushes of a dynamo machine. Now bore a hole in a glass plate, push the wire up through the plate, send the current down through the wire, sprinkling some ordinary magnetic sand, such as was once used on the writing desk, all about the wire. When the current passes we shall find on gently tapping the plate that there are arranged certain well marked lines around the wire in more or less perfect circles. Now we have mapped out what are called circular lines of force, and the region is called a field of force. Now let us see what properties this has. If in such a region we bring a pole of a magnet, and this be perfectly free to traverse around it, we shall have this magnetic pole revolving along these lines of force, and when it has gone around the circle a certain amount of work will have been done. Now suppose, in order to make clear, we split the conductor down the axis here (showing with a pencil), this way here, and so on, turning through a certain number of degrees each time and in every one of those splits we insert a card then we shall have a fan wheel, every one of these cards will represent an equi-potential surface. This floor on which I stand, supposing it to be level, is such a surface as respects gravitation. It is an equi-potential surface on which we can place a locomotive and set it going, and no work would be done in consequence of climbing up here or going down there. The floor above would also be an equi-potential surface, but the man who attempts to go up there will, of course, do work in going from one place to another. Now all of the little equi-potential surfaces about our wire are just exactly to each other as these floors are to each other. If we come from one card up to the next, we have to do some work, and the work is estimated in the same way as the work would be in getting from one of these floors to the other.

Now one case differs from the other only in the fact that the thing which produces it—notice carefully how I put this—it differs only in the fact that the thing which produces it in the one case is the current going through the wire, whereas in the other you have a great mass of rocks and material making up the mass of the earth. If we go from one of these earth planes to another we do exactly the same as we would in passing from one of these planes about the wire to another, only the lines which join these planes are said to be plumb.

If a current be passing in any given direction, say thus, it is accompanied by its magnetic field, consisting of circular lines of force and its radial planes, as we have seen; now, the theory of Maxwell requires that the effects of any variation of the current, and so of the magnetic field, shall be propagated outward with the velocity of light, the direction of the propagation being at right angles to both the current and the lines of magnetic force so-called. Now, we are very near the end of this discussion, and have reached a part which I desire that you all catch hold of. Suppose, instead of having a continuous current passing down the wire, and having this magnetic pole revolve around it like this, we put in an alternating current. Then these circles are developed around the wire; but these circles are, in their tendency, to carry the magnetic pole around constantly reversed. When you have the current go up you have one movement, and when it goes down you have the reverse. Now, there is not simply one of these lines wound about the wire, but another and another and another, out as far as you please to go. The question now is how may we soonest pass from a position on one of those lines to one on another. We do it by a motion which is exactly at right angles to them as well as to the direction of the producing currents, and an ether particle will vibrate in the same period as the current, and that vibration is light.

Now, I will go back again. Hertz found in a large hall where he carried on his experiments, that there were certain interference phenomena; for instance, the length and the strength of the induced spark was different from what it ought to be. He kept in mind that the adjoining side of the hall presented a large reflecting surface. If sound had been thrown on that it would have been reflected back. If a wave of sound struck on the adjoining wall it might be thrown off and give an interference, as two sounds not differing in pitch may give you absolute silence. He found that when he moved his apparatus from one position to another with respect to the wall, he could either cause the sparks to appear or disappear according to the relative distance at which he placed them. He thus found that his waves were about nine meters long. He calculates the time occupied in one oscillation, from the wave length and the known velocity of light, and finds that it agrees fairly well with the value calculated from the capacity and inductive capacity of the circuit employed. Now, how long are these light waves by means of which we can see? Divide your millimeter into ten million equal parts, take those as your units, write down .588, and you have the

wave length of ordinary yellow light. It is, therefore, inconceivably shorter than any distance that we are accustomed to measure, except by indirect trigonometrical processes. Now that is something like the wave length we want to see with, but the wave you get by Hertz's method is much longer than I can reach. When we can produce alternations of current sufficiently rapid, we shall have the light we want without the production of an immense amount of heat which we do not want. Now suppose we had achieved that. A wire which is now a conductor and conveys a large amount of energy from one point to another would then convey just the form of energy we want, light would beam out from the conductor and you might handle it without any heat being perceptible. It would simply burst out with light and be a luminous thread running through the air. That is what electric lighting has to reach, or otherwise it will not be perfect. It is altogether likely that no conductors with which we are at present acquainted will suffice to transmit such alternations of current as we need. Langley's experiments on the moon show it sends wave lengths greater than those which come from ice, and you have not only those, but you have all grades of vibrations up to those which are away beyond all possible means of detection except by the most refined photographic processes, and in order to get what we want—these miserable few vibrations suited to vision—we have to produce those altogether. As Professor Lodge has said, it is as if a man who wished to have less than one single octave must blow the whole organ at one time. That is what we do as a matter of fact. I now suggest one or two things that look hopeful. I am not afraid of giving this away, because I do not believe any of you will get up to-morrow and accomplish it, and I do not pretend that I see my way clear, though I tell you frankly I am going to experiment. Let us see what we can do. We can take an electric current and make it alternate—we can do that perfectly. We can make magnetic waves go back and forth and make the current alternate. Now what we may try to do is to take a beam of light which has a vibration already in parallel planes and harness that to a wire, so that it will make a current vibrate and also make the magnetic field about the wire vibrate. In other words, if you cannot do the sum, take the answer and work it backwards. That is what I propose to do, and I will hint to you exactly how I propose to do it. It cannot be done with the ordinary materials employed for conductors if it has to heat the wire. The heat in the wire is most likely due to nothing else than a series of closed electric circuits in which the electric motion is around the molecular parts. We must get something that is not a conductor in the ordinary sense. I remind you that the amount of energy expended in the movement in the high vacuum tube, in the ordinary tube where you have the most beautiful illuminations is, as a matter of fact, very small, since, when it is properly managed, the amount of heat generated in it is very small. I point out to you next that there is one substance in which we have the properties of both the conductor and the non-conductor present, and there are some very hopeful indications in that. A selenium cell, in which the selenium is so thin as to be semi-transparent when it is joined up and a battery current is put through it, is found to have its resistance diminished immediately a flash of light falls on it. The question is, does its resistance diminish immediately, or is a force set up which conspires with the electromotive force? I do not know which it is, but something may be advanced in favor of either view. Let us see how our problem works backwards. Suppose we make a polarizing apparatus by which we can polarize a long web of light. We could employ several glass plates. Let sunlight strike on this bundle at the proper angle and the light that is reflected from it is polarized. It will consist of vibrations all sorted out in parallel planes by themselves, so that they will not be fighting at cross purposes. Now let this long polarized web of light be passed through a narrow slit so as to pass directly upon, or near, the conductor in which we wish to set up an alternating electric current. If the proper conductor can be found, it should have the current set up in it and this should produce a magnetic field about it. If we put an alternating current through the conductor we shall get a series of alternating magnetic circular lines of force and light waves. Therefore, if we take the latter right by the horns, so to speak, and apply them as an electromotive force, we ought to be able to evoke the electrical current and the magnetic field at the same time. In other words, those three factors being in existence, any two of them ought to be evoked by simply giving the one. That is what ought to be brought about; whether it will be brought about with conductors or with non-conductors, I do not presume to say; but it will have to be done perhaps indirectly. The experiments of Hertz show that electrical actions can go on exactly like acoustic actions. The theory of Maxwell—and the experiments of Hertz confirm it—is that the actual wave of electro-magnetic induction is at right angles in the lines of magnetic force, and to the electrical disturbance by which they are set up. Those waves differ from light by which we see, only in their lengths. They need to be shortened. What we want is an alternating current or discharge of some sort or other, which shall enable us to produce the alternations with such frequency that the so-called conductors will break out and shine directly. If we see no way of doing it at the present time, let us try to work the problem backwards by taking light from the sun and polarizing it and applying that to the conductor, and so endeavor to set up in the conductor alternating disturbances which correspond with it in frequency, so as to note their effect, and see, if possible, precisely what we have to do. A dynamometer ought to be constructed which would be capable of measuring the effect. But with the ordinary opaque conductor such frequency means confusion among the molecules which brings about a difficulty. That is what we must get rid of.

You have been remarkably patient and I beg you will accept my thanks for the way in which you have endured what I have said, and for the courteous invitation you have given me to come here and talk. It frequently happens that one who can talk longest on a given subject knows the least about it. But I chose this subject with "set purpose and malice aforethought," not that I hoped to instruct you, but thinking that some one among you might catch an idea from my remarks and see that there were lines of experimentation which have not yet been developed, some of which I have briefly sketched. It seems a shame that we cannot have such vehicles as we choose—that we cannot get light without heat—that we cannot get the result we aim at directly without the accompaniment of so much useless waste. You are burning up tons of coal for driving machines to no purpose whatever. Where is there an end to be reached? In the light of the doctrine of the correlation of forces and conservation of energy we should be able to reach the desired result with all simplicity.

.... By affording inventors opportunities for posting themselves on the records of inventions and giving patents to all applicants therefor, many of the graver abuses of our system would be done away with, and the real inventor have a better chance of maintaining his rights.—*Alfred E. Beach.*

.... We always find in every new system that if we attempt at once to attain completion and perfection we are sure to introduce complication and expense.—*W. H. Preece.*

.... A secondary battery has one remarkable point connected with it that has not received the attention it deserves. It is this—that a battery is a kind of automatic governor; that the internal resistance of a battery that controls the external work done by the battery varies with the current that goes through it, so that if you discharge a battery with a small current you get one internal resistance. If you discharge it with a larger current you get very much less internal resistance.—*W. H. Preece.*

STATISTICS OF PATENTS ON ELECTRICAL AND RELATED INVENTIONS ISSUED FROM THE U. S. PATENT OFFICE IN 1888.

COMPILED BY THOS. D. LOCKWOOD.

THE number of patents issued during 1888 upon electrical and allied subjects, including phonographs and mechanical telephones, is 1,503. These may be classified as follows :—

1. Electric signaling, 185 patents, comprising:—

Annunciators, alarms (simple) and bells	70
Burglar alarms	11
Clocks, etc	18
Fire, and heat alarms and district and police telegraphs	46
Railroad signals and train telegraphs	40

2. Telegraphs—proper—64 patents. These I divide into :—

Autographic and automatic telegraphs	6
Morse telegraph instruments, etc	24
Multiple telegraphs	9
Printing telegraphs	18
Novel systems of telegraphy	7

3. Heavy current applications—365 patents—comprising the following sub-divisions :—

Arc lamps	27
Electrical distribution	54
Incandescent lamps	36
Lamp fixtures	18
Lighting apparatus	39
Railways and motors	137
Transmission of power, telepherage and stationary motors	54

4. Development, control and measurement of electricity —347 patents. Sub-divisions :—

Primary batteries	84
Secondary batteries	59
Dynamo and magneto electric machines	102
Galvanometers, measuring apparatus, etc	60
Dynamo regulators and governors	42

5. Conductors—insulation, etc.—76 patents. Sub-divisions:—

Cables	8
Insulated wires	17
Pole line insulators	5
Insulating materials	5
Line wires	2
Supports, cable hangers, etc	13
Underground conduits, etc	26

6. Miscellaneous and general appliances, numbering 264 patents. These comprise the following :—

Miscellaneous applications	187
Couplings, connectors and binding screws	5
Circuit breakers, closers and changers	26
Electro-magnets	9
Electro metallurgy	13
Gas lighting	24

7. Inventions in or concerning telephony—202—comprising :—

Battery or other transmitting telephones	23
Magneto or other receiving telephones	7
Guards against destructively strong currents	16
Switch-boards	5
Telephone exchange system and circuit arrangements	18
Telephonic repeaters and relays	1
Miscellaneous telephone appliances	52
Individual signals	3
Other telephone signals	8
Telephonic miscellaneous utilizations	24
Mechanical telephones and phonographs	41
Remedies for electrical disturbances	4

The only point worth notice in the above, is the number of patents issued on inventions in railways and motors, viz., 137, which brings the total of the heavy current class up to 365, one for every day, save one, of the year.

The issues of the several months were respectively:—

January	79
February	96
March	108
April	134
May	198
June	116
July	143
August	108
September	106
October	125
November	162
December	138—1,503

Showing an average of 125¼ per month, and an average of 28$\frac{9}{10}$ per week.

Considering the inventors alphabetically, we find that they count up as follows:—A, 23; B, 150; C, 85; D, 69; E, 73; F, 56; G, 57; H, 127; I, 5; J, 28; K, 46; L, 50; M, 101; N, 18; O, 18; P, 63; Q, 0; R, 73: S, 186; T, 87; U, 2; V, 40; W, 130; X, 0; Y, 5; Z, 8.

Examining these names, we find that *S* crowns the list, not as usual by the efforts of the Smith family, but by the display of energy all along the line, and chiefly in the persons of O. B. Shallenberger and C. E. Scribner, the former name appearing 26 and the latter 22 times.

B comes next with 150, W third with 130, H has the fourth and M the fifth place. Q and X alone are without representation.

The letter I comes out in 1888 with unusual vigor, and reaches the figure 5; while J, by reason of no less than 9 Johnsons, reaches 28; Johnson having fairly beaten Jones.

N, holds its present place by the exertions of a *Newman;* who took out one-third of the entire number, while Tesla and Zalinski also do their best for their respective initials.

The entire number of patents of all classes issued (less, however, a few withdrawn) is 19,585.

The electrical patents amount, therefore, to 7.67 per cent. of the whole.

POINTERS.

.... "COINERS" used to stand for *counterfeiters*. This term might be well employed in the same sense to describe many of the utterers of new words. "Electromotive" for an electric locomotive—a specious but particularly base counterfeit—is one of the newest atrocities.—*T. D. Lockwood.*

.... IT ought to be more generally known that the "ohmic resistance" of an electric conductor, referred to by Sir William Thomson in his inaugural address before the Electrical Engineers of London, increases directly in proportion to its feetic length, and inversely in the ratio of its poundic weight.—*George B. Prescott, Jr.*

.... BRAKES that save the power instead of wasting it are of purely English extraction, but their conception has recently come across the Atlantic with such a strong Yankee accent, that it might pass for having been born and bred in the States.—*Professor Ayrton.*

.... THE practicability of the transmission of energy by currents is assured, and the economy of doing this is a mere matter of calculation. It is a question of the relative cost of the transmission of energy by wire.—*W. H. Preece.*

.... HAVING now become fairly satisfied with the performance of one system of distribution, we naturally look forward to being able to distribute on an alternative plan at some future date.—*Professor George Forbes.*

.... THE engineer feels that steam and electricity in his hands have done more to economize labor, to cheapen life, to increase wealth, to promote international friendship, to alleviate suffering, to ward off war, to encourage peace, than all the legislation and all the verbosity of the politician.—*W. H. Preece.*

.... IT seems but a very short time since the question of distribution was being discussed and seemed quite hopeless, and I think all of us will feel a great relief when the time arrives that a system of distribution combined with storage batteries, gives us a more efficient and a more economical system of distribution than that which is alone at our disposal at present.—*Professor George Forbes.*

.... EVERYONE should know his Morse alphabet, and people should learn how to write. Nine-tenths of the telegraphic errors made are due to the execrable caligraphy of the present day.—*W. H. Preece.*

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.[1]

BY G. W. DE TUNZELMANN, B. SC.

H. Hertz has been engaged for some time past in a series of researches on electrical oscillations, which have led to results of very exceptional interest, as was pointed out by Professor Fitzgerald in his inaugural address to section A of the British Association last week; and as these results throw considerable light on the nature of electrical action, it will be of interest to readers of *The Electrician* to have a connected account of the investigations, to which I therefore propose to devote a short series of papers.

In Hertz's first paper on the subject, viz., "On Very Rapid Electrical Oscillations" (Wied. *Ann.*, vol. xxxi., page 421, 1887), he refers to a paper by Colley, "On some New Methods for Observing Electrical Oscillations, with Applications" (*ibid.*, vol. xxvi., page 432), who calls attention to the fact that Sir William Thomson in 1853 first showed the possibility of producing electrical oscillations by the discharge of a charged conductor, and gives references to all the investigations in the same direction which were known to him.

For the benefit of readers who may wish to pursue the subject further the list is reproduced below.

Sir W. Thomson, "Mathematical and Physical Papers," vol. i., page 540.

Feddersen, Poggendorff's *Annalen*, vol. ciii., page 69, 1858; vol. cviii., page 497, 1859; vol. cxii., page 452, 1861; vol. cxiii., page 437, 1861; vol. cxv., page 336, 1862; vol. cxvi., page 132, 1862.

Kirchhoff, "Gesammelte Abhandlungen," page 168, containing remarks on, and corrections of some of Feddersen's results.

Von Helmholtz, "Gesammelte Abhandlungen." vol. i, page 531.

Von Oettingen, Poggendorff's *Annalen*, vol. cxv., page 115, 1862, and Jubelband, page 269, 1874.

Bernstein, Poggendorff's *Annalen*, vol. xiii., page 142, 1828.

Schiller, Poggendorff's *Annalen*, vol. clii., page 535, 1872.

L. Lorenz, Wiedemann's *Annalen*, vol. vii., page 161, 1879.

Mouton, Thèse, Paris, 1876. *Journal des Physique*, vol. vi., pages 5 and 46, 1876.

Kolacek, Beiblätter zu Wiedemann's *Annalen*, vol. vii., p. 541, 1883 (abstract of a paper published in the reports of the Bohemian Scientific Society in 1882).

Olearsky, Verhandlungen der Academie von Krakau, vol. vii., p. 141, 1882.

Oberbeck, Wiedemann's *Annalen*, vol. xvii., pp. 816 and 1,040, 1882; vol. xix., pp. 213 and 265, 1883.

Bichat et Blondlot, *Comptes Rendus*, vol. xciv., p. 1,590, 1882.

According to these investigations, the electrical oscillations produced in an open circuit by means of an induction coil are measured by ten thousandths of a second, while in the case of the oscillatory discharge of a Leyden jar they are about a hundred times as rapid, as was shown by Feddersen.

According to theory, still more rapid oscillations should be possible in an open circuit of wire of good conducting material, provided its ends are not connected with conductors of any considerable capacity; but it is not possible to determine from theory whether measurable oscillations are actually produced. Some observations of Hertz's led him to believe that under certain circumstances oscillations of this kind were produced, and his researches show that this is so, and that the oscillations are about a hundred times as rapid as those observed by Feddersen; so that their periods are measured by hundred millionths of a second, and, therefore, they occupy a position intermediate between acoustic and luminous vibrations.

Preliminary experiments.—It is known that if in the secondary circuit of an induction coil there be inserted, in addition to the ordinary air space, across which sparks pass, a Riess spark micrometer, with its poles joined by a long wire, the discharge will pass across the air space of the micrometer in preference to following the path of least resistance through the wire, provided this air space does not exceed a certain limit, and it is upon this principle that lightning protectors for telegraph lines are constructed. It might be expected that the sparks could be made to disappear by diminishing the length and resistance of the connecting wire; but Hertz finds that though the length of the sparks can be diminished in this way, it is almost impossible to get rid of them entirely, and they can still be observed when the balls of the micrometer are connected by a thick copper wire only a few centimeters in length.

This shows that there must be variations in the potential measurable in hundredths of a volt in a portion of the circuit only a few centimeters in length, and it also gives an indirect proof of the enormous rapidity of the discharge, for the difference of potential between the micrometer knobs can only be due to self-induction in the connecting wire. Now the time occupied by variations in the potential of one of the knobs must be of the same order as that in which these variations can be transmitted through a short length of a good conductor to the second knob. The resistance of the wire connecting the knobs is found to be without sensible effect on the results.

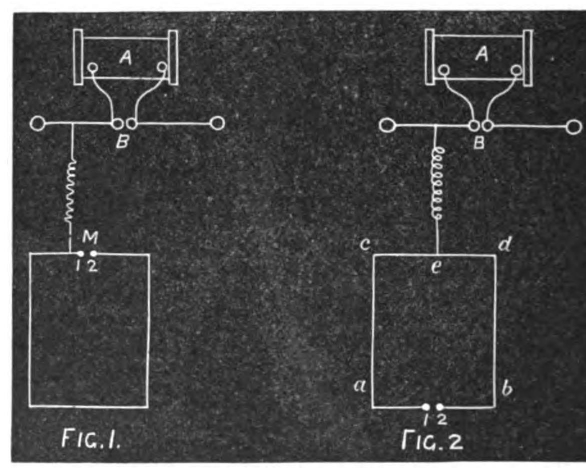


FIG. 1. FIG. 2.

In figure 1, A is an induction coil and B a discharger. The wire connecting the knobs 1 and 2 of the spark micrometer M, consists of a rectangle, half a meter in length, of copper wire 2 millimeters in diameter. This rectangle is connected with the secondary circuit of the coil in the manner shown in the diagram, and when the coil is in action sparks, sometimes several millimeters in length, are seen to pass between the knobs 1 and 2, showing that there are violent electrical oscillations, not only in the secondary circuit itself, but in any conductor in contact with it. This experiment shows even more clearly than the previous one that the rapidity of the oscillations is comparable with the velocity of transmission of electrical disturbances through the copper wire, which according to all the evidence at our disposal is nearly equal to the velocity of light.

In order to obtain micrometer sparks some millimeters in length a powerful induction coil is required, and the one used by Hertz was 52 centimeters in length and 20 centimeters in diameter, provided with a mercury contact breaker, and excited by six large Bunsen cells. The discharger terminals consisted of brass knobs 3 centimeters in diameter. The experiments showed that the phenomenon depends to a very great extent on the nature of the sparks at the discharger, the micrometer sparks being found to be much weaker when the discharge in the secondary circuit

1. From the *Electrician* (London).

took place between two points, or between a point and a plate, than when knobs were used. The micrometer sparks were also found to be greatly enfeebled when the secondary discharge took place in a rarified gas, and also when the sparks in the secondary were less than half a centimeter in length, while, on the other hand, if they exceeded 1½ centimeters the sparks could no longer be observed between the micrometer knobs. The length of secondary spark which was found to give the best results, and which was, therefore, employed in the further observations, was about three-quarters of a centimeter.

Very slight differences in the nature of the secondary sparks were found to have great effect on those at the micrometer, and Hertz states that after some practice he was able to determine at once from the sound and appearance of the secondary spark whether it was of a kind to give the most powerful effects at the micrometer. The sparks which gave the best results were of a brilliant white color, only slightly jagged, and accompanied by a sharp crack.

The influence of the spark is readily shown by increasing the distance between the discharger knobs beyond the striking distance, when the micrometer sparks disappear entirely, although the variations of potential are now greater than before. The length of the micrometer circuit has naturally an important influence on the length of the spark, as the greater its length the greater will be the retardation of the electrical wave in its passage through it from one knob of the micrometer to the other.

The material, the resistance, and the diameter of the wire of which the micrometer circuit is formed have very little influence on the spark. The potential variations cannot, therefore, be due to the resistance, and this was to be expected, for the rate of propagation of an electrical disturbance along a conductor depends mainly on its capacity and coefficient of self-induction, and only to a very small extent on its resistance. The length of the wire connecting the micrometer circuit with the secondary circuit of the coil is also found to have very little influence, provided it does not exceed a few meters in length. The electrical disturbances must therefore traverse it without undergoing any appreciable change. The position of the point of the micrometer circuit which is joined to the secondary circuit is, on the other hand, of the greatest importance, as would be expected, for if the point is placed symmetrically with respect to the two micrometer knobs the variations of potential will reach the latter in the same phase, and there will be no effect, as is verified by observation. If the two branches of the micrometer circuit on each side of the point of contact of the connection with the secondary are not symmetrical the spark cannot be made to disappear entirely; but a minimum effect is obtained when the point of contact is about half way between the micrometer knobs. This point may be called the null point.

Fig. 2 shows the arrangement employed, e being the null point of the rectangular circuit, which is 125 centimeters long by 80 centimeters broad. When the point of contact is at a or b, sparks of from 3 to 4 millimeters in length are observed, when it is at e no sparks are seen; but they can be made to reappear by shifting the point of contact a few centimeters to the right or left of the null point. It should be noted that sparks only a few hundredths of a millimeter in length can be observed. If, when the point of contact is at e, another conductor is placed in contact with one of the micrometer knobs the sparks reappear.

Now, the addition of this conductor cannot produce any alteration in the time taken by the disturbances proceeding from e to reach the knobs, and, therefore, the phenomenon cannot be due simply to single waves in the directions $c\,a$ and $d\,b$ respectively, but must be due to repeated reflection of the waves until a condition of stationary vibration is attained, and the addition of the conductor to one of the knobs must diminish or prevent the reflection of the waves from that terminal. It must be assumed, then, that definite oscillations are set up in the micrometer circuit just as an elastic bar is thrown into definite vibrations by blows from a hammer. If this assumption is correct, the condition for the disappearance of the sparks at M will be that the vibration periods of the two branches e 1 and e 2 shall be equal. These periods are determined by the products of the coefficients of self-induction of these conductors into the capacities of their terminals, and are practically independent of their resistances.

In confirmation of this, it is found that if when the point of contact is at e and the sparks have been made to reappear by connecting a conductor with one of the knobs, this conductor is replaced by one of greater capacity, the sparking is greatly increased. If a conductor of equal capacity is connected with the other micrometer knob the sparks disappear again; the effect of the first conductor can also be counteracted by shifting the point of contact towards it, thereby diminishing the self-induction in that branch. The conclusions were further confirmed by the results obtained when coils of copper wire were inserted into one or other, and then into both of the branches of the micrometer circuit.

Hertz supposed that as the self-induction of iron wires is, for slow alternations, from eight to ten times that of copper wires, therefore a short iron wire would balance a long copper one; but this was not found to be the case, and he concludes that, owing to the great rapidity of the alternations, the magnetism of the iron is unable to follow them, and therefore has no effect on the self-induction.

In a note in Wiedemann's *Annalen*, vol. xxxi., page 543, Dr. Hertz states that since the publication of his paper in the same volume, he had found that von Bezold had published a paper in 1870 (Poggendorff's *Annalen*, vol. cxl., page 541), in which he had arrived by a different method of experimenting at similar results and conclusions as those given by him under the head of Preliminary Experiments.

(*To be continued.*)

ABSTRACTS AND EXTRACTS.

FLASHED FILAMENTS IN LAMPS.

HAS anyone observed that the result of the so-called flashing process is necessarily to produce a conductor which tapers to the ends? Wherever the temperature of the surface is hottest, for any cause, there a more rapid deposition of carbon will take place; and where the temperature is lower a less rapid deposition will occur. Now, consider a simple arched conductor, which we will suppose to be of initially equal section from end to end. When rendered incandescent, the end portions being connected to non-incandescent mountings, will be cooled by them. Those parts which are subjected to the end-cooling will necessarily be at a lower temperature, and will therefore receive a less thick deposit of carbon. Again, in the case of conductors which are bent, not merely into an arch, but into a loop of one or more turns. Those portions of the conductor which lie near to one another will radiate to one another, instead of merely radiating out to cooler objects. They will consequently help to raise one another's temperature. Were the conductor, then, initially a wire of perfectly uniform section, those parts which are thus mutually heated will tend to receive a thicker coating of deposited carbon than the straight limbs leading to the mounts.

In every case the result of flashing will be to so build up the size of the conductor that every part shall glow with equal radiance, in spite of its accidental position, whether subjected to a cooling effect or to a heating effect from the adjacent portions of the lamp. Flashing will not, as often alleged, reduce all portions of the conductor to equal size or equal resistance per unit of length, and it weakens the conductor mechanically by leaving it thinner near its mountings.

The existence of this tapering structure can be actually observed by the eye in some flashed lamps, and is capable of measurement by a micrometer gauge.

The following measurements were made by the writer upon a flashed 105-volt "Victoria" lamp. Measurements bracketed together were made at the same point in two diameters approximately at right angles to one another :—

DIAMETER IN MILLIMETERS.

At bow of loop	.145 .150	mean .1475
Half-way down limbs	.150 .140	" .1437
" " "	.135 .150	
At end, near mount	.095 .105	" .1012
" " "	.110 .105	
At other end, near mount	.090 .100	
" " " "	.105 .100	

In another similar lamp the mean diameter of bow and limbs of the arch was .130 millimeter, and that of the ends close to the mount .100.—PROFESSOR SILVANUS P. THOMPSON in *The Electrician* (London).

THE ELECTRICAL RESISTANCE OF IRON.

IN text books the resistance of commercial iron is generally given as 6.56 times that of copper, but according to the results of recent experiments made by Mr. W. H. Preece, F. R. S., it is actually only 6.034 times that of copper. The exact determination of the resistance of iron is of considerable importance, especially now, when through the operations of the copper syndicate the price of this metal has been forced up to a figure which precludes its use for many electrical purposes. The following table, which we extract from a recent post-office circular, gives the specific resistance of various metals. The resistance in C. G. S. units of a cubic centimeter at 60° F. is as follows :—

Silver	1609
Copper	1642
Pure iron	9753
Commercial iron	9907

The increase of resistance with temperature from t to t_1° F, for iron can be determined by the formula

$$R = r\,(1.0027)^{t_1 - t}$$

where r is the resistance at t° and R at t_1°. If the temperature be given in centigrades, the formula is

$$R = r\,(1.0048)^{t_1 - t}.$$

For telegraph lines, "low" and "high" resistance iron wire is now used, the former being either charcoal iron or a special blend, and the following table gives the mechanical properties of these wires :—

Gauge No.	Weight per mile.	Diameter.	Breaking weight. Low resistance. Blend.	Breaking weight. Low resistance. Charcoal.	Breaking weight. High resistance.	Elongation per cent. Low resistance. Blend.	Elongation per cent. Low resistance. Charcoal.	Elongation per cent. High resistance.
	Lbs.	In.	Lbs.	Lbs.	Lbs.			
6	600	0.209	1920	1725	2100	16-17	16–17	17–18
7½	400	0.171	1280	1150	1390	"	"	"
10½	200	0.121	640	575	695	"	"	"

—*Industries.*

THE TELEPHONE IN SWEDEN.

IT may be doubted whether in any other country in the world the telephone has made such progress as in Sweden. Thus a Swedish technical journal publishes statistics up to 1886 showing that the City of Stockholm, in proportion to the number of inhabitants, takes precedence in respect of the number of telephones in use over 12 European capitals and three great cities in the United States, as the following figures purport to show :—

	Number of inhabitants.	Number of apparatus.	Per 10,000 individuals.
Stockholm	215,000	4,978	232
Berlin	1,280,000	4,248	33
London	4,765,000	4,193	9
Paris	2,800,000	4,054	14
Rome	300,000	2,054	68
Copenhagen	274,000	1,336	49
Amsterdam	335,000	1,195	36
St. Petersburg	850,000	1,100	13
Vienna	1,200,000	946	8
Brussels	380,000	803	21
Helsingfors	46,000	575	125
Madrid	478,000	270	6
New York	1,500,000	3,700	25
Chicago	600,000	3,500	58
Brooklyn	650,000	2,375	37

The journal adds that since then the number of telephones used in Stockholm has greatly increased ; but for some cities no statistics more recent are available.—*Electrical Review* (London).

THE METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED), LONDON.

THE WESTINGHOUSE STATION IN SARDINIA STREET.

AT an extraordinary general meeting of the shareholders of the Metropolitan Electric Supply Co. (Limited), on Dec. 4, 1888, the following address was made by the chairman of the company, Sir John Pender, K. C. M. G.

Gentlemen :—We have called you together to-day for two purposes—first, to inform you as to the progress the company has made since August last and its present position and prospects ; and, secondly, to put before you a resolution approving an agreement made by the board, under the power of the articles of association, to vary the original agreement entered into between this company and the Whitehall company for the purchase of the property and the undertaking of the Whitehall company. And first, with respect to the work done. You are aware that the company took over from the Whitehall company the important works and installation which the latter had established at Whitehall avenue. That station, which has about 10,000-light capacity, was opened on the 5th October last, and the directors had hoped that the full capacity of lighting would be taken up by customers in seven or eight months. Instead of this, the full capacity of the station is taken up already. In about two months orders were booked for nearly 9,000 lamps, and the mains for connecting them are being laid as fast as possible. The Avenue Theatre, the Hotel Victoria in Northumberland avenue, and other places have been lighted for some time, and the managers have written expressing their satisfaction with the supply, and among the more recent contracts secured to be worked from the Whitehall station are the Grand Hotel, Messrs. Hampton's large furniture warehouses in Pall Mall, St. Martin's Church, and other places. The company's mains are being laid underground throughout the whole of the Charing-cross district, and have already been laid across Northumberland avenue, West Strand, and Trafalgar square, without causing any appreciable interruption to the traffic. Mr. Gordon informs me that the guaranteed revenue from the contracts made and to be carried on from the Whitehall works is £13,500 a year, and that other contracts, expected to be completed in a few days, will be another £1,000, making altogether £14,500. The working expenses, including rent, salaries, wages, and 10 per cent. for depreciation, are estimated at £6,000, leaving a profit of £8,500 a year, on these installations, which, I think, is fairly satisfactory, seeing that the capital represented by these works is not much over £40,000. As to the Sardinia street works, the buildings in Sardinia street are in hand, and a large body of men are employed on them. We have put up a map here in which you see the Sardinia street station. I may say without any hesitation or fear of contradiction that that station will be one of the most important in London. It embraces the important residential property about Bloomsbury, the shops, hotels, and large restaurants in Holborn, the important newspaper, publishing and printing establishments about Fleet street, and the banks, shops, and numerous buildings in the East Strand district. That station will, I think, have altogether 50,000 lights, and so far as we can see now and judge from

the inquiries that are made, it will not be a long time after the installation is completed before that will be fully occupied; and if the results upon the 50,000 lights are at all in proportion to what we now see from the practical working of the Whitehall works, I think we may congratulate ourselves on being in a position to make very handsome dividends. I may mention that the machinery for this station has been ordered from the Westinghouse company, and the bulk of it will be delivered in a very short time. The object in ordering this machinery from the Westinghouse company is this—that they have put down in America 116 installations, all of which have been successful, and the principle we have gone upon—what has been the policy of this company, because we have not been idle during the last six months—has been to take the very best thing in existence, and to utilize it for our purposes. This American system is considered almost perfect, as far as it has gone. We are inviting tenders from English contractors for another installation, and so we shall work one against the other, and we shall have the full advantage of what I may call contractors' competition. I think the result of that will be to give us the best thing of the kind up to the present moment. I do not mean to say that in electricity, as in other things, there is not very great progress. You will see that that is the case when I tell you that it is scarcely 10 years ago since electric lighting was a laboratory experiment, whereas it is now almost becoming universal. I may go further and say this: It is not more than 25 years since submarine telegraphy was first introduced, and there is now £40,000,000 sterling in the bottom of the sea, the major portion of it paying a fair dividend. That shows that we do not know to what extent electricity can be carried; but, so far as we have gone, it seems that the electric light is to be the light of the future. I have no hesitation in saying, if you look at the prospectus we put before you—it was based on a good deal of experience—you will find that what we said in regard to the American installations ought to be thoroughly borne out also in regard to English installations. The company also took over from the Whitehall company the extensive and valuable property for electric lighting purposes, the Waterloo bridge wharf, which is admirably adapted for supplying the whole of the Strand district, and which can take the machinery required for working 150,000 lamps. That, I think, will be perhaps the largest installation in our system. I want you to understand that we have not gone, in the slightest degree, upon a speculative or experimental policy. We are laying down installations which we know will be successful, so far as the mechanical part of them is concerned, and we believe that the light will be fully taken up by the public; and, therefore, I think we are not over sanguine in looking forward to very successful results. That installation is one which, I hope, will, before another year is out, be in active operation. We know that there are very formidable competitors in the market at the present moment. I greatly admire the enterprise of the Grosvenor Gallery combination, the gentlemen connected with which are of the highest eminence. They have great practical scientific knowledge among them, but they are trying the biggest experiment ever tried in electric lighting, so I am informed by scientific men. I hope their experiments may be successful. I like to see these great efforts of science successful, and I believe if this experiment is successful it will be a very remarkable step in electrical progress. We have been more cautious, probably more prudent. We are not putting all our eggs in one basket. We are so putting our different installations that we can work them collectively or separately; consequently we are not likely to break down as a whole. You can see the object of that, and we have acted upon the advice of our eminent scientific advisers. Therefore, every installation of ours will stand alone, but every installation will stand shoulder to shoulder with its neighboring installation if so required. Since August last (I have said that we have not been idle) the directors have secured several other sites for works. One is Greenmore wharf, a large wharf adjoining Southwark bridge, which is suited for lighting the City of London proper. We have also obtained a site in Southmews, Manchester square, for the Marylebone district. Negotiations are proceeding for other sites. The specifications for the machinery for the Greenmore wharf have been sent out, and tenders are expected in a week or two from various responsible English firms. Specifications for the other sites will go out immediately. With regard to the Strand district, the company has secured a monopoly of the lighting of the new Salisbury estate, consisting of Salisbury and Cecil streets, for the ground of which alone a sum of £200,000 has recently been paid. That will probably be one of the most remarkable improvements in London. I cannot say much more with regard to our prospects. In the summer it was said they were encouraging, and I think if I went over article by article in the prospectus put before you, I could justify every item in it. The second portion of our business to-day I hope will also be satisfactory, because it is very much for the benefit of the company's interests, though probably not so much to the satisfaction of others, who have been working for the last two or three years, and who consider themselves very badly paid indeed for their work and property. I may say at once that the short result of what we ask you to confirm to-day is to reduce by just one-half the purchase money payable by the company for the property and rights which they agreed to take over from the Whitehall company. The price is reduced from £79,000, the sum named in the prospectus as having been fixed by the vendors, the Whitehall company, to the very modest sum of £40,000. This, you will see, is practically reducing the purchase money by one-half, and I am sure every shareholder in this company will be glad that this reduction is to be made. The vendors are willing to make the reduction, though they are by no means satisfied with the decision that Sir Frederick Bramwell and Sir Whittaker Ellis have arrived at with respect to the value of the property. It was, of course, to be expected that the vendors would take a more favorable view of their undertaking than what I may call cold-blooded but very experienced gentlemen who sat down to value what was placed before them. The vendors made their arrangements with the company at a time when there were really no shareholders but themselves and their friends in the company. No man could then, nor can even now, estimate absolutely what is the value of the undertaking we have purchased. I have told you to-day of our prospects. Probably a year or two hence our stock may be worth twice or thrice what it is to-day, so you see how difficult it is to value a thing which has not been fully realized. Therefore, in this valuation, though it is not so stated, probably nothing has been taken into consideration as to the prospective value of the company. I do not know what was in the minds of the valuers, and they have, perhaps, wisely given no reason for their decision, but from the course of inquiries which they have made very carefully in respect to the properties actually transferred I have no doubt they have omitted from their calculations these elements of future value which the vendors not unreasonably considered so important. I may add that the vendors would be perfectly willing to take back their properties if the company did not desire to go on with the purchase; but I believe I am right in saying that every member of the board is convinced that the property is well worth, and more than worth, the sum we have now decided to pay for it. One other matter ought also to be mentioned, that is with respect to the provisional order which the board of trade had granted before the prospectus was issued. This provisional order gave to the company valuable rights over the parish of St. James's, Westminster, and St. Martin's-in-the-Fields; and when the Duke of Buckingham, as chairman of committees of the house of lords, refused to suspend the standing order which prevented the second reading of the government bill to confirm that provisional order, the board of trade promised to use their good offices to support a private bill to enable the company to secure the confirmation of that provisional order in the next session. The loss of this provisional order, in the sense I have mentioned, occurred between the time when the agreement was made and the prospectus prepared and the date of its actual issue, and I think the valuers must have made a large reduction from the original price on account of the unfortunate slip, which was occasioned by no fault of the promoters but through the delays in parliament. When the prospectus was issued, and the shares were so readily and so largely subscribed, and so many new shareholders came into the company, the directors sat down to consider the position and the course they should take in consequence of the changes which had occurred, and they came to the conclusion that there should be, in the interests of all parties concerned, an independent valuation of the property which the company was to purchase. Several of the directors were themselves interested in the properties which had been acquired and were to be sold by the Whitehall company, and this made it the more necessary that such a valuation should be taken. The South Metropolitan Co. was threatened with opposition by the Whitehall company, and it was really this that brought about the combination of the two parties, one represented by Sir George Elliot and his friends who had taken a deep interest in this question, and the other by Mr. Balfour and his friends, who had invested largely in the Whitehall court enterprise, and who had founded the Whitehall Electric Co. The agreement referred to in the circular, which has been sent to you, dated 12th December, 1888, will now be read to you by the solicitor. It has been made especially under power of the articles of association, which contain an important clause authorizing this being done. The solicitor will now read the agreement.

Later, at the same meeting, Sir John Pender made further remarks, as follows:—

Now, gentlemen, we have given you to-day a straightforward statement, and I wish to give you also a little further information, so that on leaving this room you will understand that the gentlemen connected with this enterprise have made up their minds to make it go ahead. We believe the time has come, and that there is a great deal of good useful paying work to be done with electric lighting. This is the further information I will give you. The company has given notice of a bill in parliament to obtain parliamentary powers to carry on the works for St. James's, Westminster, St. Martin's-in-the-Fields, and Waterloo bridge, which will include the ground covered by the provisional order which was obtained last summer, but which was not confirmed by parliament, although the board of trade did all in their power to get the bill passed. Notices have also been given for provisional orders in four districts—Mid-London, North London,

South London and West London. It may be that we shall not proceed with all these, but we thought it wise to give the notices, without which we could not proceed. In view of all the works executed and in hand, and what is proposed to be done in the future, the directors think the prospects of the company, as put before you to-day, are very encouraging indeed. There is another point. Some people have said to me, "But there are more electric lighting companies in existence than can possibly be required." But the population of this mighty city is 5,000,000 of people, and if the electric light is successful (and I believe it must become the light of the future), we shall require to spend £34,000,000 to £35,-000,000 sterling before we can do the work required. Therefore, when I find respectable people—people of high position having money to spend—coming forward to take part in this work I hail them with great satisfaction. There is plenty of good paying work for us all. As I said before, electricity is yet in its infancy, and the more that science can be brought to bear upon it the more we shall have of this light. The light is doing a great sanitary work, and with its use the air remains pure, and there is less heat. I have not a word to say against gas. I believe that gas, being the essence of heat from coal, has a great deal of work before it, but in another field than that of lighting. Those interested in gas must look to apply it to other purposes. The light of the future is to be the electric light. That finishes the business of the day, gentlemen.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Decision for the Board of Electrical Control Against the U. S. Illuminating Co.; the Latter Co. Sues the Commissioners for Damages.—Annual Report on the Subways.—Rapid Transit Sought for New York.—An Electrical Course at Columbia College.—Mr. E. N. Dickerson's Lecture at the Electric Club.—Comments on the U. S. Supreme Court Decision in the Bate Case.—Prospective Removal of the Westinghouse Electric Co.'s General Office to New York.

JUDGE LAWRENCE, of the Supreme Court, has sustained the position taken by the Board of Electrical Control in the suit brought against that body by the United States Illuminating Co. The company will now be compelled to abide by any and all orders of the board without questioning its jurisdiction or right. Judge Lawrence alluded to the wisdom of the legislature in giving full power to the board to act. He thought that while the Illuminating company brought forward the testimony of undoubted experts that the conduit was not feasible or practicable, the evidence produced by the board—notably the affidavit of the city electrician of Chicago—was equally strong and effective.

A few days after this decision, the United States Illuminating Co. brought suit for damages against Commissioners Hess, Moss and Gibbons in the sum of $250,000.

The Board of Electrical Control has made its second annual report to the Governor, the previous reports having been made by the old Subway Commission, which was practically the same body. The total length of trench excavated in the city is 240,-155 feet, and the total length of single duct for telegraph and telephone service is 2,287,880 feet, less 325,429 feet for distributing service and connections. Estimating the duct as having a capacity of eighty wires, the total mileage of wire provided for is 34,665. It is estimated that the conduits for electric light and power service have a capacity for nearly 600 miles of wire, exclusive of the Edison system. The number of poles removed is given at 776, and 946 miles of wire have been taken down. The Metropolitan Telephone & Telegraph, the Western Union, the Brush and the Edison companies, and the city fire alarm telegraph have in all 4,453 miles of wire underground, but it is admitted that there are to-day more miles of wire overhead than existed a year ago.

Our new mayor announces his purpose to enforce the Subway law. He has assumed the presidency of the board, but no radical change of policy has yet been announced. At a recent meeting of the board, the Consolidated Telegraph and Electrical Subway Co. reported that 2,287,880 feet of duct had been thus far constructed for telegraph and telephone wires, and 316,776 for Edison incandescent lighting. About 45 miles of trench had been opened and filled. The miles of electrical wires in the subway on Jan. 1 were :—

	Miles.
Metropolitan Telegraph and Telephone Co.	4,062.32
Western Union Telegraph Co.	39.08
Brush Electric Light Co.	8.87
Edison company	192.23
New York City Fire Telegraph	101.02

The subway is now completed between the Battery and Fifty-eighth street in Broadway, also along Church street, College place, West Broadway, South Fifth avenue and Sixth avenue. Other routes, solely for electric light service, extend from Fourteenth to Fifty-eighth streets on Broadway, from Eighteenth to Fifty-eighth streets on Sixth avenue, and on various cross-town streets.

Since the expose of the Sugar Refinery Co.'s affairs, the *Herald* has instituted a diligent search for electrical sensations. In its issues of the 18th and 19th of January, it charges Mr. E. T. Gilliland and John C. Tomlinson with retaining a quarter million dollars rightfully belonging to Mr. Thomas A. Edison for the sale of certain rights to the phonograph. The libel formed the subject of an Associated Press report, and seems very likely to cause trouble for some one. The parties concerned refuse to make any statements. It is however, known that Messrs. Gilliland and Tomlinson have ceased all connection with the Edison interests. Mr. Gilliland has interested himself with Mr. O. E. Madden in the Empire City Electric Co. and the Non-Magnetic Watch Co. of America.

Anyone who has a plan for providing New York with rapid transit will be welcomed with dollars and honors by our new Mayor. Mr. Frank J. Sprague, in his lecture before the Institute of Electrical Engineers last year, did not overestimate what has now become a most serious question. The crowding on the elevated roads is little short of disgraceful. At least seventy-five per cent. of the passengers travel several miles, and the large number of stoppages necessitates an enormous number of people devoting a considerable portion of each day in getting to and from their places of business. A recent bill in the legislature for an "L" road on Broadway called forth most emphatic protests.

The trustees of Columbia College have decided to establish a department of electrical engineering. They have provided for the appointment of an instructor in electrical engineering and an assistant for teaching the theoretical branches of mathematical physics as applied to electricity and its relations to heat, and magnetism.

A motor, closely allied to that of Mr. Keeley, has made its appearance in this city. Mr. E. D. Speer, of Cincinnati, is the inventor and promoter. Mr. Speer modestly claims to save 95% of the power of the fuel. His concern is called the Non-Exhaust Steam Engine Co.

The committee of the Board of Trade and Transportation has presented its bill to the legislature regulating telephone rates to $72.00 per year in cities of over 500,000 inhabitants, and $36.00 in all other cities.

Mr. E. N. Dickerson, well known to the electrical fraternity through his work as counsel for the American Bell Telephone Co., lectured before the Electric Club Jan'y 17th on "The Steam Engine." Mr. Dickerson called attention to the enormous loss in the conversion of coal into steam with our present type of engines, pointing out that in electrical engineering the question of cost of supplying current is one most largely dependent upon the cost of fuel.

The jubilant tone of the observations printed by the daily press as coming from President Johnson and Secretary Hastings of the Edison Electric Light Co. in regard to the commercial effect of the Supreme Court decision of January 21, in the Bate case, does not meet with an altogether hearty response from the legal department. On the contrary, the decision proved, from the latter point of view, to be little better than a Dead Sea apple. The best efforts of able counsel, to say nothing of a large amount of money, were employed to secure an early decision of this case, in the hope that the Supreme Court would hold that the foreign patent limitation of the statute related to the date of application and not to the date of issue of an American patent. Almost the whole force of argument of counsel was directed to this one point, which, had it proved successful, would have freed Mr. Edison's patents from all limitations, and possibly have placed the competitors of the Edison company practically at its mercy. But the Court, it seems, skillfully avoided the necessity of passing upon this point, and so left the law exactly where the counsel of the other electric companies have all along contended it was. It was a bitter disappointment to the Edison interests, and one which is not materially assuaged by the circumstance that some of the competing concerns will be materially benefited by the effect upon their patents of the favorable decision on the remaining point.

It is rumored that in consequence of the recent consolidation of interests between the Westinghouse and United States companies, the general offices of the first named company will be removed to this city in the course of two or three months.

NEW YORK, January 26, 1889.

.... WITH a series motor, or a motor excited by a constant current, you may vary the load as much as you please and the volts will vary, but the current will remain perfectly constant; the pressure may be made to vary as you like, and the current will remain perfectly constant.—*Professor George Forbes.*

.... THE great advantage of high-speed engines, is that the steam has no time to condense, or, rather, that very little of it is condensed in comparison with the amount utilized.—*Gisbert Kapp.*

PHILADELPHIA.

A City Electric Lighting Plant Under Discussion.—The Street Lighting Contracts for the Next Year.—The Suit of the State of Pennsylvania Against the Western Union and Baltimore and Ohio Telegraph Companies; a Statement by Dr. Norvin Green.

THE probability that the special committee of councils investigating the subject of electric lighting for the city will report in favor of the municipality establishing its own plant, and that this recommendation will lead to a discussion of the entire matter in councils, has raised the question as to the ownership of the numerous abandoned conduits under some of the streets. There are several of these structures under Chestnut and Market streets, which might possibly be utilized for the city's wires if these should ever be buried.

City treasurer-elect Bardsley said that while he did not wish to express a positive opinion without examining the ordinances, he was confident that the conduits had become the property of the city by the failure of the companies to make use of them within the time limits fixed by the ordinances. "It is doubtful, however," he said, "whether any of them are of any value. The city has the right to put in two or three wires in the conduits laid in Market street by the Western Union Telegraph and Bell Telephone companies, and these might be used to advantage if the city should establish its own plant and bury its wires." Mr. Bardsley favored the city doing its own lighting if the companies shall not come down in their prices.

Estimates as to the cost of the proposed plant vary widely. The Pennsylvania railroad found that it could secure a plant of 1,000 arc lamps capacity for $100,000, and the cost to the city would probably be little greater. The necessity for more lamps is generally admitted, and the plant required would be of at least 2,000 or 3,000 lamps capacity. The cost of this is estimated at anywhere from $250,000 to $500,000.

The bids for illuminating the streets by the electric arc lamps next year were opened a few days ago by director Wagner and chief Walker, of the electrical department.

According to the specifications of the contracts, the director can have any light tested and rejected, if not up to the standard. The lights are to burn from sunset to sunrise. It is further specified that lights which burn less than nine hours each night from September to March 31, and less than six hours from April 1 to August 31, will not be paid for. The failure of the lights for two nights, or any other violation of the specification will cause the annulment of the contract.

All the bidders will receive contracts, as each company bid only for the territory it covers. There will be an average decrease in cost of 2½ cents for each lamp per night from the price paid during the current year.

There is an appropriation of $130,000 for the purpose of paying the expense incurred by the electric lights. The bids are as follows:—

Germantown Electric Light Co. (Thomson-Houston) old borough of Germantown, 2,000 c. p., 55 cents (same as this year).

Frankford Electric Light and Power Co. (Thomson-Houston), Bridge street below Asylum turnpike and east of it, 55 cents (same as this year). Northern Electric Light Co. (Thomson-Houston), north from and not including Poplar street, and east from and including Second street to the Delaware river, 1,200 c. p., 48 cents (last year, 49 cents).

Brush Electric Light Co., Brush system, 2,000 c. p., between the Delaware and Schuylkill rivers, south of Washington avenue, 54 cents; from the south side of Spruce street to the north side of Washington avenue, between the rivers, 47½ cents; between south side of Market street and north side of Spruce, and Delaware and Schuylkill, 45 cents; between north side of Market street, south side of Callowhill, west side of Broad and Schuylkill river, 47½ cents. West Philadelphia, 50 cents.

United States Electric Light Co. (U. S. system), 2,000 c. p., between the north side of Market street and north side of Poplar, east of Broad to the Delaware, 49 cents (this year 50 cents). Philadelphia Electric Lighting Co. (Thomson-Houston, north side of Callowhill street and Erie avenue, east side of Broad street and the Schuylkill river, 45 cents (this year, 47½ cents). Between south side of Eighth, Callowhill and north side of Poplar from Eighth to Broad, 47½ cents (this year 52½ cents). Between the north side of Callowhill street and Erie avenue, east side of Broad and Schuylkill river, 45 cents (this year 69½ cents).

Wissahickon Electric Lighting Co. (American system), 700 to 800 c. p., between Allegheny avenue, twenty-eighth ward, and Leverington avenue, twenty-first ward, 55 cents.

The joint special committee appointed to ascertain if a more desirable method can be adopted by the city for lighting the streets with electric lights, held a meeting a few days since.

The city at the present time is paying $129,000 a year for the lighting of 755 electric arc lights on the streets.

This is said to be excessive, and for the sum of $300,000 it is claimed that the city could put in a plant that would provide 3,000 lights at an expense of $90,000 a year.

When the meeting was called to order it was moved that, considering that the contracts for '89 had been awarded, that the meeting be postponed for the present, as there was no need fo hurrying the matter.

On the other side, it was urged that it would take some time to consider the matter, and require minute consideration, as it is very important, and if the committee should act favorably on the subject it will take nearly a year to construct the plant.

Chief Walker of the electrical department said, in answer to a question, that it was the intention of the electrical bureau to test all the lights next year, and if they were not up to the standard, the company supplying the same would receive no money for the lights.

On a motion to consult with the directors of public safety and public works and obtain all the information possible on the matter, the meeting adjourned to meet again at the call of the chair.

City-solicitor Warwick and councilmen generally will watch with interest the suit that has been instituted by attorney-general Kirkpatrick against the Western Union and the Baltimore and Ohio Telegraph companies and the Baltimore and Ohio company of Pennsylvania, with the view of having their property and franchises forfeited to the state for violating the state constitution.

The charge against the Western Union is that it bought a competing line, and the Baltimore and Ohio company is charged with selling out to a business rival. The attorney-general has become possessed of irrefutable information that Jay Gould and his colleagues on October 5, 1887, bought out the entire capital stock of the Baltimore and Ohio concern for $5,000,000, though the par value of the same was but $3,875,000. The attorney-eneral has asked for a writ of *quo warranto* to summon the companies before the court to show by what authority they continue business in the state and why all their franchises, rights and privileges should not be forfeited to the state. Judge Simonton granted the writ and made it returnable on January 29.

When the Baltimore and Ohio company obtained permission from councils to erect its poles and string its wires in this city the company gave a bond of $50,000 conditioned that it should never pass into the hands of a rival concern. City-solicitor Warwick has taken steps to sue on the bond, but has met with many obstacles, chiefly on account of his inability to produce evidence showing that the actual purchase of the Baltimore and Ohio plant was made by the Western Union company.

Dr. Norvin Green, the president of the Western Union, in speaking about the suit said:—

"There is no good ground for the suit, and we are not at all disturbed by it. Just who the parties that have instituted the suit are I do not know, as I have not seen the papers. At the time of the purchase of the Baltimore and Ohio property by us we guarded against the very points that are raised by this suit. Under the United States law of 1886, all telegraph companies were given the right to operate their lines in all states, and even if there is a Pennsylvania state law, as is alleged, it would have no effect in the face of the United States law. The United States Supreme Court has decided over and over again that telegraph business is interstate commerce, and cannot be interfered with by state action or statute.

There is no consolidation of the Western Union and the Baltimore and Ohio Telegraph companies. The latter is still maintained as a separate and competing company. Then again the Western Union, when it made the purchase, did not buy that portion that was operated under the Pennsylvania charter. The Baltimore and Ohio parent company was chartered under the Maryland laws. In each one of the other states where the company built lines, separate state charters were secured, and each of these separate companies was leased by the original company. The Pennsylvania company was not included in the purchase, we expressly refusing to purchase, as we were aware of the stringent state charter and did not care to enter into any controversy over it."

PHILADELPHIA, January 18, 1889.

BOSTON.

Municipal Recommendations in Several Cities.—A Satisfactory Burglar Alarm Test.—Quincy Telephone Subscribers Tired of Disturbance from Electric Light Wires.—Damages Secured for Bad Telephone Service at Naugatuck.—Boston Aldermen Satisfied with Telephone Rates.—The Western Union Telegraph Co. Resenting Taxation.—Report of Committee of Aldermen on Overhead Wires.—Trouble at Malden Between the Electric Light and Telephone Companies.—Sprague Electric Cars Running on the Brookline Branch of the West End Railway Co.

IT is interesting to observe the recommendations of the newly inaugurated mayors of our state, and to note among others the following: The mayor of Cambridge recommends the introduction of police signals.—The newly-elected mayor of Worcester suggests that their police signal system be extended.—His honor of Quincy, thinks there should be an improvement in the fire alarm system.—Police signals are declared a public necessity by the mayor of Chelsea.—In Lowell, the city of spindles, the newly-elected chief officer thinks that the police department should have

a signal system.—Hon. E. S. Bradford, of Springfield, believes in investigating the quality and expense of lighting by gas and electricity, and the expense of all-night burning.—Mr. Jackson, of Fall River, recommends the adoption of police signals; electric lights, he said, are a great improvement over gas, and it is well to increase their number as fast as the city's finances will permit. The old town of Newburyport has a mayor; he thinks the electric lights in the streets should be burned later than midnight.—Perhaps he belongs to a lodge. In the ancient borough of Watertown, a police signal system is recommended by the new comer. In all the inaugurals that have come to hand some application of electricity is commended or recommended. It is significant to observe the general request for police signals.

At a meeting of the directors of the Brookline National Bank in Brookline, on the afternoon of the 8th inst., one of the directors thought it would be a brilliant idea to test the burglar alarm—the bank being connected with the police station by a private wire. The alarm was set off, and within an incredibly short time police officer Watson was standing before the directors. The test was satisfactory. A good thing to do once in a while.

About 25 telephone subscribers of Quincy, including eight physicians, have notified the telephone company that they shall cease to be subscribers if the telephone service is not improved by altering its relations with the electric light wires.

Recently E. A. Sanders, the general manager of the G. M. R. Shoe Co., of Naugatuck, won a suit at Naugatuck against the Southern New England Telephone Co. Justice Gibb decided for the plaintiff in $100 and costs. The suit was brought for failure to properly transmit a message while the plaintiff had urgent need for good service, the call being for a physician. Inattention and insulting language on the part of a telephone operator in the main office was alleged.

On the 26th of December, alderman McLaughlin, from a special committee appointed to investigate telephone rates as paid by the City of Boston, made a report, in which comparisons are made with prices paid in other large cities. The conclusion of the committee is that the City of Boston has a more favorable arrangement for telephone service than most other cities.

At the last meeting of the board of aldermen for 1888, a communication was received from the mayor, returning without his signature the order granting the New England Telephone and Telegraph Co. leave to attach its wires to poles on the new Harvard bridge, the mayor claiming that the control of the bridge rests with the commissioners of Harvard bridge. The order was reconsidered, and on motion of C. W. Smith, was referred to the next board.

Assistant attorney-general Henry C. Bliss, on behalf of the Commonwealth, and George S. Hale for the defendant, have been taking testimony in the case, in the United States Circuit Court, of the Commonwealth *vs.* the Western Union Telegraph Co., for unpaid taxes for the years 1886-7, amounting to about $30,000. The company declines payment on the ground that it pays a local tax on real estate in New York; and it also contends that the levy made by the Commonwealth is a tax upon interstate business, and, furthermore, that it is a tax upon a federal franchise, which is contrary to law, as laid down in a national book case.

The committee of the Boston board of aldermen, appointed October 8th, last "to enquire into and report what action can be taken by this board to protect the lives of the firemen and property from danger by the overhead electric wires," after visiting New York and other cities, have reported in substance that, from the information obtained, they are of the opinion that there is no difficulty in placing all heavily charged wires underground that are now in use in our city, and the only serious question in this regard is that of expense. These wires as at present located are undoubtedly very dangerous to the public, and especially so to firemen in the discharge of their duties at fires, and fatal accidents occur frequently every year from contact with these exposed wires, and will continue so long as the overhead system is allowed to exist. The committee, therefore, recommend that immediate steps be taken by the board of aldermen to require that all heavily charged wires be placed underground, and that application be made to the general court for the necessary authority. The report was ordered printed, and referred to the new board of aldermen.

In consequence of the interference of strong current in electric light wires with telephone circuits on the same poles, the New England Telephone and Telegraph Co. recently requested the Malden Electric Co. to remove the electric wires on the telephone company's poles in Malden and Melrose The electric light company, instead of removing the wires, proceeded to place more of them on the poles. On the 5th, a number of these electric wires were removed by the telephone company in Melrose. This is a growing evil, and something will have to be done to satisfy telephone subscribers.

The electric railway absorbs the attention of the average Bostonian at the present time. The first trial trip of a car over the entire line from Oak square, Brighton, to Park square, was made on Monday night, the 31st of December, and the result was generally satisfactory. This branch of the West End Railway Co. employs the Sprague system. On Tuesday, January 1st., president Whitney and the directors of the West End street railway made a trip in one of the cars, and yesterday two of them were running most of the afternoon, carrying passengers the same as any other car of the company. The writer was one of those who tested the new conveyance yesterday, and he was, in common with all on the car, well pleased with the experiment. The line extends from Oak square, Brighton, through Washington and Cambridge streets to Allston, thence through Harvard street to Beacon street in Brookline, through Beacon street to West Chester park on the Back Bay, through West Chester park to Boylston, through Boylston to Church, through Church to Providence street, then to Park square and to Boylston street, and back through Boylston and the other streets. A branch line extends through Beacon street, Brookline, from its junction with Harvard street to Chestnut Hill reservoir. From Brighton to near the point on Beacon street where is the entrance to the Back Bay park, the overhead system of wires is used for the supply of motive power, but the rest of the way to Park square the conduit system is used. The conduit is located just outside of the track, so that where there is a double track both the conduits are between them.

On the 28th of December, Hon. Prentiss Cummings appeared before the railroad commissioners in behalf of the petition of the West End Street Railway Co., for authority to use the overhead electric system upon its line between Arlington and Bowdoin square, Boston via Cambridge. The electrical engineer of the company was also present, and said that either the overhead wire or the conduit system could be used without a particle of damage to man or beast. He said that the company would be ready within two weeks to run half-hourly trips of passenger cars propelled by electricity, between Brighton and Park square. When the men have become accustomed to the new motor, the trips will be made oftener. No one appeared in opposition to the road's petition, and it will undoubtedly be granted.

BOSTON, January 16, 1889.

CHICAGO.

The Chicago City Council Come to Terms with the Telephone Company.—A Bill Regulating Telephone Charges in the Illinois Legislature.—Chicago Electric Club Meetings; Discussion of Formulæ for the Insulation of Distributing Conductors.—The Postal Telegraph Co. Mulcted in Damages for Error in a Commercial Message.—Professor Barrett on the New City Lighting Plant.—Train Lighting on the Milwaukee and St. Paul R. R.—A New Dynamo by Mr. S. J. M. Bear.—An Interesting Installation of Accumulators.

THE city council found the solution of the telephone problem early in January. An ordinance was adopted which in its essential features was satisfactory to the aldermen and the telephone company. The measure is a compromise. The aldermen gave up the effort to secure a deduction of subscribers' rentals, and the company pays more for its privileges than it wished to do. The measure meets with general satisfaction. Chicagoans are tired of the squabble, especially those who have desired telephones but were unable to secure them, inasmuch as the company was not allowed to extend its wires. The ordinance has one feature which will tend to make it popular. It is understood that the $30,000 which the city will receive from the telephone company will be used in extending the electric light system. The principal conditions of the ordinance are contained in the following extract:—

Where the wires are laid underground the company shall, for the purpose of reaching and connecting their subscribers and branch offices, have the privilege of bringing the said wires, conductors, and cables to the surface within every four blocks and attaching the same to houses and carrying them over roofs, provided the consent is first obtained from the owner to whose property they propose to attach said wires, conductors and cables, and said wires shall be kept at least 12 feet above the surface of the roofs, except in such buildings as the wires are to enter, and said company may in so doing, cross streets, alleys, and city property with wires grouped in cables * * * It shall, through its president or secretary, file with the city controller, the first day of January and July of each year, a statement of its gross receipts from the telephone business done within the city of Chicago for the six months next preceding such statement, and the said company shall pay into the city treasury three per cent. on such gross receipts, and the company, during the term for which the ordinance is granted, shall not increase to its present or future subscribers the rates for telephone service now established. Also, that with the acceptance of the ordinance there shall be filed by the said company a schedule showing the rates charged for telephone service at the date of the passage of this ordinance within the limits of the city of Chicago.

* * * * * * *

Nothing in this ordinance contained shall be construed or taken as preventing the city of Chicago, whenever it shall be authorized so to do, from passing an ordinance regulating the rates to be charged by telephone companies for the rental of telephones, or for the licensing of telephone companies, it being the intention of this ordinance that the city of Chicago shall in no way surrender any rights it may have, or may hereafter acquire, to license telephone companies or to regulate the prices to be charged for telephones. But if the city shall acquire the right to regulate rates and exercise the same, the payment of the three per cent. shall cease.

There are provisions requiring the telephone company not to enter into combination with similar corporations under penalty of forfeiting its charter; also reserving the right of the city to grant franchises to competing companies. The duration of the ordinance is twenty years.

At the council meeting, January 7th, an attempt was made to reconsider the ordinance. Mayor Roche said he had signed the

ordinance believing that it was for the best interests of the city. The ordinance did not in any way interfere with the regulation of the telephone rates when the city had the requisite authority so to do. He said he favored $75 as a rate, but there was no way in which such a price could be secured at present. If the city refused to come to terms with the company it simply lost the three per cent. of the latter's gross revenue. The attempt to reconsider failed.

An ordinance has been introduced requesting the legislature to grant the council the authority to reduce the rate of telephone rentals. Fault has already been found with it. It has been asked why should its provisions be limited to the exercise of power over the telephone company; why should it not include all corporations operating under city franchises, such as gas companies and electric light companies.

Mr. O'Toole, of the town of Lake, has introduced a bill in the General Assembly, making the rentals of telephones in Illinois as follows:—When a subscriber has one telephone the rate shall be $3 per month; when he has two telephones, $2.50 per month. Between villages connected by telephone the charge shall be 15 cents for the first five minutes and five cents for each subsequent five minutes. The telephone company in Chicago could not stand any such deduction, and does not fear that the bill will become a law.

The Chicago Electric Club held the first meeting of the year, January 7th. Mr. F. S. Terry, the treasurer, presented his report, which showed the receipts of last year to be $2,644.83 and the expenditures $2,939.39. The deficit is fully covered by dues not paid in. Mr. W. A. Kreidler, the secretary, presented his report. He referred to the fact that the club had made a substantial gain in membership during the year and had been the means of laying before the electrical fraternity a highly interesting series of papers which had attracted attention not only in the United States but abroad. He spoke of the quarters now occupied by the club, and emphasized the necessity of securing rooms better adapted to the needs of the organization. The lease would expire he said in May, and the club after that time should have new quarters in which the cuisine especially would be of a more satisfactory kind. The club then listened to a discussion on the subject of insulation which had been brought before the meeting in this way:—C. C. Haskins, the city inspector of electric lights, invited representatives of the several electric light companies to meet and consider the subject of insulation. They responded, and at their meeting Mr. H. Ward Leonard proposed the following formula, to ascertain the requisite insulation on all circuits:—

$$\text{Insulation} = \frac{E \times 10{,}000}{C}.$$

These gentlemen without taking action turned the subject over to the club for its consideration. It was briefly considered at a meeting in December, and was set down as a special order for January 7th. At this meeting Professor Badt, who led in the discussion, proposed these formulæ for the determination of the necessary insulation:

$$\text{Direct current } R = \frac{E \times 25{,}000}{C}$$

$$\text{Arc system } R = \frac{E \times 1{,}000}{L}$$

$$\text{Alternating transformer } R = \frac{E \times 25{,}000}{C \times L}$$

where L = length of circuit.

These formulæ were discussed by Messrs. Cutter, Schillinglow, Thompson, and others. At the meeting of the club, January 14, the discussion of these formulæ was continued. Messrs. Leonard, Sperry, Thompson, Cutter, Sargent, Wilmerding, and others, spoke. After a two hours' session it was decided to adopt the second formula of Professor Badt, $R = \frac{E \times 1{,}000}{L}$ as the one to determine the resistance in all cases. A number of examples was worked out, and it seemed to be the general opinion that the results even in extreme cases were not unjust.

Judge Baker recently handed down a decision of considerable importance to telegraph companies. C. D. Lathrop & Co., secured some months ago a judgment against the Postal Telegraph & Cable Co. on account of errors in messages transmitted to New York over defendant's lines. The messages related to transactions in coffee. The attorney for the defendant asked for a new trial on the ground that the company was not liable for the errors because the printed heading on the telegraph message contained an exemption from liability; because Lathrop & Co. did not notify the company of the importance of the despatches, or of the damage likely to result from errors; and because the transactions of Lathrop & Co. were in the nature of gambling transactions. Judge Baker decided that, notwithstanding the printed exemption from liability on the despatch blanks, the telegraph company was bound to use ordinary care in the transmission of telegrams, and the fact of the errors raised a presumption of negligence. The messages being commercial messages the company had sufficient notice of their importance. As to the transactions being gambling transactions, the court said they were not necessarily illegal. Whether the purchases were legal depended on whether they were actual purchases, and the jury had decided they were. The court overruled the motion for a new trial, and entered judgment on the verdict for $6,698, the difference in prices of purchase and sale, resulting from the telegraph company's error. The telegraph company appealed.

Professor Barrett says the new electric light system in Chicago will prove highly economical. When the entire city is lighted by the better illuminant the saving from the displacement of gas lamps will aggregate, he estimates, about $250,000. His calculation is based on the saving from the displacement of 1,000 gas lamps by the arc lights already in operation. The 1,000 gas jets cost $26,000 annually. Estimating that four per cent. is paid as interest on the money invested in the plant, Professor Barrett says there will still be a yearly saving of about $9,000. The system is giving the greatest satisfaction, and the city electrical department is already overwhelmed with applications for the extension of the system. No trouble has been experienced with the underground mains.

The executive committee of the National Electric Light Association has leased a portion of the Exposition building in Chicago, for holding the February convention. The daily sessions will be held in one of the art rooms. A large amount of space will be reserved for exhibits.

The Chicago, Milwaukee & St. Paul Railroad Co. is now lighting two of its trains by electricity. The lights are supplied directly with current from the dynamo until midnight, when a battery of accumulators takes the load. The installation was made by Leonard & Izard.

Mr. S. J. M. Bear, a Chicago inventor, has written to a daily paper stating that he has designed a dynamo which will produce twice as much current per horse-power as any generator in use. He makes this statement in his article descriptive of the machine: "As more glow lamps are paralleled in circuit the applied power is lessened resulting in more light from less coal."

The Accumulator company, represented by Conant & Hood, Chicago, will make an interesting installation in the residence of Potter Palmer, on the Lake Shore drive. A 175-light United States dynamo operated by an Otto gas engine, will charge a set of accumulators for the supply of current for lamps in the house. The residence is wired for 250 lamps. When it is desired to light them all, the accumulators will supply half the lamps and the dynamo will furnish current directly for the balance of the lights.

CHICAGO, January 22, 1889.

MONTREAL.

New Contract of the Royal Electric Co. for Public Lighting; the Royal Company's Incandescent Business.—The Westinghouse Central Station of the Consumers' Gas Co., at Toronto.—An Edison Station Projected in the same City.—The Heisler Company also on the Ground.—Damage to Electric Service by Sleet, Gale and Fire.—Quick Restoration of the Quebec Telephone Service.—Electric Lighting Notes.

THE Royal Electric Co., notwithstanding public protests and counter proposals from other companies, have been awarded the contract for lighting Montreal, or rather an extension of time, and of the number of lamps to be used. As I have before stated, the Royal company's previous contract would have expired in two years. The new contract extends the period by three years—making it five years instead of two—and increases the number of lamps to 800 arcs, an increase of about 680 lamps. Montreal will thus be more generally lighted probably than any city of its size. A Mr. Fuller has, however, entered a suit to declare the Royal company's contract illegal, but nothing is expected to come of it.

The Royal company find orders for incandescent lights coming in much faster than they are able to install them, and are now 800 lights behind on order. Their new station will be in operation in a few days, from which all demands can be supplied.

The City of Toronto called for bids for an extension of the city lighting by 200 arc lamps Bids ranged as low as 24 cents. None of the tenders, however, were accepted, and the question of an increase in the city lighting is still an open one.

Toronto, however, is to be well supplied with incandescent lighting by the Consumers' Gas Co., who will use the Westinghouse company's system and sell light by meter. The plant as at present laid out will have a capacity of 3,000 lights, but will undoubtedly be increased very rapidly, as Toronto has no central station incandescent lighting at present. The Edison company have also organized a company there, planning for an ultimate station capacity of 5,000 lights.

The Heisler company have made strong efforts to establish a company in Toronto, but apparently without success as yet.

The vicinity of Toronto and as far east as Quebec was visited last week by a very severe sleet storm. The Bell telephone system, at Kingston, was completely demolished. The telegraph service of the Grand Trunk Railway in that vicinity was entirely down for several days. During the gale of the 10th inst., much

damage was done to lines and service. The Bell telephone exchange, at Quebec, was burned out on the 7th inst.; the fire is attributed to an electric light cross. New switch-boards were shipped from Montreal, and under the supervision of division manager McFarlane, work was rapidly carried on, so that by the time the damage caused by the sleet of the same night was repaired, the exchange was in working order, many of the subscribers not being aware of the fire damage.

The Royal Electric Co. report a sale of 30 arcs at Sherbrooke, and an increase of 20 arcs at Pillow, Hersey & Co.'s, Montreal. They will also supply 50 arcs at the ice palace during the carnival, and 31 arcs at the court house.

The Edison company report 600 lights in addition to their Toronto plant.

The Reliance company are to put in an arc plant at Prescott, Ont.

The Edison station at Sault St. Marie will soon be in operation.

The Chandivere Electric Light Co. (U. S. system), of Ottawa, have increased their station capacity 500 incandescents, making a capacity of 2,000 in all.

MONTREAL, January 20, 1889.

LITERATURE.

Practical Electrical Measurements. By J. SWINBURNE. London: H. Alabaster Gatehouse & Co.; New York: D. Van Nostrand, 1888.

ON the somewhat unusual assumption that needless accuracy has been the prevailing characteristic of previous treatises on electrical measurements Mr. Swinburne discusses in this volume what he terms workshop measurements as distinguished from more refined laboratory practice. It is mainly a reprint of articles that have appeared in the English *Electrical Review*, and after being revised and amplified they are now published as an attractive hand-book neatly bound in flexible covers. Whatever may be the general opinion regarding the practical utility of the apparatus and methods described in standard text books, such as Ayrton's and Stewart & Gee's, it is doubtful whether any experienced workman in the field of heavy electrical engineering, will complain that the measurements so far designed for this particular class of measurements are needlessly accurate, or that the tests ordinarily applied are amenable to any such criticism. The author comes to his task, however, so well equipped by practical experience, that there appears to be a basis for his very pronounced confidence. His selection and treatment of the subject-matter is decidedly original, and a large amount of stereotyped matter, which is usually deemed indispensable to works on electrical subjects, is conspicuous by its absence. It is a source of regret, however, that, notwithstanding his somewhat didactic style, the author often unwisely assumes so much knowledge of the subject in hand, on the part of the reader, that essential detail is frequently omitted. This is particularly noticeable in the treatment of dynamos and motors.

The opening chapter discusses the measurement of resistance, and describes several modifications and practical forms of the Kirchhoff and Thomson bridges for the measurement of very small resistances, such as armatures. The much felt want of a cheap and yet approximately accurate Wheatstone bridge is strongly expressed, and ought to merit the attention of instrument manufacturers. The measurement of leaks—a somewhat neglected subject—is considered at length, and the use of ohmmeters discussed. It is difficult to tell just what the author's opinion of the latter instruments is, but he evidently thinks they ought to be calibrated throughout their scale. He also holds the same view, apparently, regarding all the meters—either for current, potential or energy—which he afterwards describes, and, doubtless, most of the users of such instruments will agree with him. This is in fact, a serious reflection on the character of the commercial test instruments now produced, for it must be obvious that almost any combination of iron and copper will produce an effective instrument with an arbitrary scale, and it ought to be equally obvious that the real requirements for an electrical measuring instrument are that it shall be direct reading and have a scale of uniform divisions.

The greater part of the remainder of the book is devoted to a description of many of the numerous modern instruments designed for the measurement of electrical quantities, and of various methods of standardizing them. The defects peculiar to the different instruments are pointed out with considerable minuteness, and a multitude of corrections for temperature, contacts, etc., are treated as of grave importance. Most of the simple methods described are considered inaccurate, and in short the author's critical tendency is so pronounced, that the reader is inclined to the opinion that he is not so opposed to needless accuracy as he imagines.

Mr. Swinburne appears to have a *penchant* for measuring all electrical quantities by means of the fall of potential along wires of known resistance. All sorts and sizes of resistance boxes adapted to this object, including a number of "ohm" and "mho" switches for combining the wires, are described in detail. Of course potentiometer tests can be made accurately if sufficient care is observed, and they are often the most convenient, but to assume that they are particularly adapted to workshop calibrations of ammeters and voltmeters, is easier than to prove. For reliable work they are essentially laboratory methods as they involve the use of accurately adjusted resistances and standard cells, both of which are subject to temperature corrections, and of at least two sensitive galvanometers. It is doubtful if any person of experience who should be required to calibrate a large number of instruments, would apply the method to any other purpose than that of standardizing a standard instrument.

Although the author claims, in the preface to this work, to have selected for description only such instruments as are best suited for commercial use on account of their approximate accuracy combined with portability and cheapness, he describes such apparatus as Sir William Thomson's new gravity instruments, which are known to require the most delicate manipulation of any yet devised. He also refers to the Forbes's meter and the Ayrton & Perry bicycle wheel voltmeter, neither of which have ever been placed on the market. The employment of storage batteries as the source of current for calibration work is strongly recommended, and several convenient switches for transposing them when applied to this purpose are described. Standard cells and voltameters as applicable to calibrations are adequately discussed, and there are two instructive chapters on the respective subjects of meters and the winding of voltmeters. The portions of the work relating to dynamos, batteries and incandescent lamps are, however, merely discursive and lack detail and preciseness. This seems to be rather unfortunate, for after spending so much time in learning how to standardize instruments, the student would like to be taught how to use them. To persons more or less experienced these chapters will not be without interest, as the author criticises some prevailing notions in a pungent and effective style.

The concluding chapter on alternating currents, while not lacking in information, is written in a style hardly consistent with the character of the book. It is a rambling discussion of the subject, suggesting various practical tests, but not describing them with sufficient fullness to enable those unfamiliar with the subject to apply them. The work is original, useful, but incomplete.

Die Erzeugung und Verteilung der Electricität in Zentral-Stationen. Von Dr. MARTIN KRIEG. Band ii. Die Erzeugung und Verteilung der Electricität durch Gleichstrom-Maschinen mit und ohne Verbindung von Akkumulatoren. Magdesburg, 1888. A. & R. Faber.

THE numerous types of dynamos already in use and the innumerable modifications constantly introduced in the apparatus of central stations, render it impossible for any author in the limits of a readable book to describe fully the equipment of even the most important electrical plants at the date of his writing. The sudden demand for all kinds of electric lighting apparatus that has grown up since the establishment of the Edison lighting station in New York (1882), has called into being many ephemeral systems for supplying plants. The market just now is filled with machines and mechanisms whose value has not received any adequate test. Meanwhile, a process of selection is going on which will result in the "survival of the fittest." To attempt for some years a complete description of all the machines and kinds of plants in successful operation would be a premature undertaking. Anything, however, which assists in classifying knowledge regarding what is in use and thus promoting the selection of the "fittest," is valuable. The book under notice is calculated, in this way, to aid materially in the evolution of the ideal central station.

If the first volume (on the Generation and Distribution of Electricity by Alternate Current Machines and Converters, which has not yet come under our inspection) be as suggestive as the second, it is well worth reading. The author's aim is to impart information and not to educate. He realizes the embarrassment to which the existence of numerous systems exposes him, and he wisely confines himself to a detailed description of a few of the more important. In the nine chapters, into which he divides the 375 pages, he discusses in the first four, prominent types of machines and accumulators, and systems of distribution and regulation. The rest of the book is given up to descriptions of methods of installation, disposition of conductors, description of certain central stations, and calculations of the cost and profit of central stations.

The machines described in the first chapter were chosen with judgment. The descriptions, aided in most cases by excellent illustrations, are concise yet simple. The power required and volt-amperes furnished are indicated in tabular form. The chapters on accumulators is rather more complete. This might be expected for two reasons: first, our information regarding accumulators has been rather meagre; and, second, the bias of

the author is, apparently, for the more extended use of accumulator in central stations. Indeed, it may be said that the tendency of the book is in that direction. It should be added that this position is well maintained. Dr. Krieg's arguments for the use of accumulators on the ground of economy and convenience will be hard to meet.

A good indication of the fact that methods of constructing more economical and convenient secondary batteries are receiving close attention and with some degree of success, is the secrecy which certain establishments maintain regarding their processes. The author mentions this secrecy to account for his lack of detail in some cases. Statistics are given of the accumulators of the Electrical Power Storage Co., the Julien system, the de Khotinsky, Fasbaky-Schenck, and Tudor. The Tudor batteries were used by Dr. Kohlrausch in the experiments on which were based the conclusions regarding accumulators, an abstract of which was published in the ELECTRICAL ENGINEER, for November, 1888, and which are given in this book.

Dr. Krieg's treatment of conductors and auxiliary apparatus is marked by the conciseness already noted, which is, nevertheless, not inconsistent with completeness. He devotes considerable space to various systems of underground cables, making his descriptions quite exhaustive.

The chapters on the building and economical operation of a central station are methods of computation, and are the best in the book. It is unfortunate that such good text as that of this chapter should be spoiled by muddy cuts. There is no reason why the curves so elaborately worked out should not be presented to the reader in a form easier of interpretation. The estimates for the cost of construction and maintenance of an electrical plant are carefully made, and form the basis of the recommendation for a more extended use of accumulators. The fact that the larger the plant (within limits) the less is the cost per lamp, is well brought out in the last table of estimates given. In the last chapter, on methods of computation, several of the curves are very ingenious, and afford a simple method of computation. The descriptions, in the eighth chapter, of the large central stations are interesting if not important.

The book is a useful one, and we bespeak for it the cordial reception desired by the author. The good judgment shown in the selection of material and in the author's views, dispose the reader to give attention and consideration to suggestions which may at first seem unusual or even questionable.

NEW PERIODICALS.

Electric Power. Conducted by RALPH W. POPE and GEORGE H. STOCKBRIDGE. HENRY W. POPE, Business Manager. Published monthly by the Electric Power Publishing Company, 150 Broadway, New York.

We have received the first number of this journal, dated January, 1889. As its title implies the publication will be devoted chiefly to the interests of the transmission of power by electricity. In their announcement the editors say: "It is the purpose of this journal to assist in bringing to public attention the manifold advantages of electric power."

Readers of the ELECTRICAL ENGINEER will recall Mr. Ralph W. Pope's connection with this journal under its former title—THE ELECTRICIAN AND ELECTRICAL ENGINEER—as one of its editors, with pleasant reminiscences of his broad views and genial wit; while Mr. Stockbridge's former association with the *Electrical World*, in charge of its patent bureau, is fresh in the minds of all who keep up acquaintance with electrical publications.

The initial number of *Electric Power* may doubtless be taken as a fair example of its scope and quality, and in both respects it fully deserves attention in electrical circles, as well as from all who are interested in industrial pursuits. Besides important original articles by David E. Lain, Thos. D. Lockwood, G. R. Blodgett and S. D. Greene, it contains many well-chosen selections and abstracts, together with a large number of technical and industrial notes, bearing chiefly upon the electric motor and its uses.

The journal is a quarto of twenty-four pages, exclusive of advertisements, and we are restrained from a warm commendation of its make-up and general appearance only by its resemblance to THE ELECTRICAL ENGINEER in those respects. We can hardly appropriate to ourselves the flattery of imitation in this instance, inasmuch as the best features of our journal are due in large measure to the intelligent work devoted to it some years ago by one of the editors of the present new journal.

The Telephone. A Review of Electrical Science. Published Fortnightly. London: 18 Charing Cross.

"The space of our paper will to a great extent be devoted to telephonic intelligence and to improvements and inventions connected with the Telephone."

The above quotation is from the editorial announcement found in No. 1, vol. 1, of the new electrical journal just started in London. The editors say further: "The attention which we propose bestowing upon this subject will, however, not be an exclusive one, and part of the paper, and a part to which we attach the utmost importance, will be reserved for original articles on Electrical Science, both theoretical and practical, * * *."

This periodical begins its career with an issue which is not only very readable by all interested in electricity, but must prove of special interest in telephone circles. It contains technical, practical and statistical articles relating to the telephone, and a fair amount of other matter touching theoretical and applied electricity generally. We shall look with much interest for the succeeding numbers of *The Telephone.*

NEWS AND NOTES.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF JANUARY 8th, 1889.

The January meeting of the Institute of Electrical Engineers was held at the College of the City of New York, at 8 P. M.

On motion of Mr. T. C. Martin, Mr. Francis W. Jones was elected chairman for the meeting.

There being no routine business before the meeting, the chairman immediately presented Mr. E. G. Acheson, who read his paper on "Lightning Arresters and the Photographic Study of Self-Induction." (See page 47.)

The Chairman—Gentlemen, you have before you a very interesting subject. It is unnecessary for me to say how well and ably it has been placed before you. The paper is now before you for discussion. It is suggested that I call upon Dr. Moses.

Dr. Otto A. Moses—As I have had a very good opportunity of knowing the careful methods in which Mr. Acheson directs his thought experimentally, I feel to a certain extent diffident upon being called upon so suddenly to express any doubts as to the correctness of his experiments. He has conferred with me occasionally on the subject in the course of his experiments. There are one or two things that might tend to start this discussion which I will suggest, so that some who are present here who I know have taken great interest in this matter may continue it. If Mr. Acheson will look at figure 2 (page—) in these various experiments with the Leyden jar, he will remark where he has a wire coiled around the metallic coating of the conductor, he has substituted there a supplementary coil of two or three turns, and has brought the terminal of it to a certain distance from the interior conductor. He has done that, as I understand, as a substitute for the wire W, in both cases making the air space the same. Will Mr. Acheson please repeat what was the object of that substitution so that I may direct another question afterwards?

Mr. Acheson—The doctor is mistaken in regard to its being the equivalent of the wire W. In order to ground it I have assumed that the outer surface of the jar J represents the earth, and I connect the outer surface of the lead to that by a short metallic connection, in order to reduce it to one potential as we would have it in practice.

Dr. Moses—Were the lengths equal of the two wires—the one wrapped around the lead coating and the wire W?

Mr. Acheson—No, sir. And the coil of the wire E about the lead in this case was probably accidental in the sketch, because in reality it was only one turn around it, so that there was no parallel effect there.

Dr. Moses—There was another point that I would like to be enlightened upon. You mention in one case that you experimented with copper and iron wire and used wires of the same diameter in both cases. Did you take into consideration at all the conductivity of the wires, or did you think that unimportant?

Mr. Acheson—Owing to the existence of that air space I assumed it was wholly useless to consider the resistance of the wire, as we had an infinite resistance already in the circuit; I mean in the space A.

Dr. Moses—In that space A did you consider the difference in the size of the condensing surfaces of N and A?

Mr. Acheson—Yes; I attempted to make a measurement of the capacity of the apparatus with the jar removed; but although I had a constant on the galvanometer—a very high constant—I failed to get any capacity, not because there was none there, for we knew that there was, but it was beyond the reach of my instruments. The size of the balls was considered of course, and the ball X was made of a size that would allow me to obtain a sufficiently high electromotive force without spinning off, as it would do where it was very small.

Dr. Moses—By what means did you cause your rotations?

Mr. Acheson—By hand. I used in fact Mrs. Acheson's sewing machine as the motive power.

Dr. Moses—In photograph No. 13 (page 53), when you shifted the machine——

Mr. Acheson—I shifted the position of the plate—the sensitive plate, my revolving disc remaining in its former position. The

disc being here rotating, immediately back of it was my sensitive plate, and in order to produce this first spot marked 1 I had the plate at a certain height and raised it higher for the succeeding ones twice.

Dr. Moses—Perhaps these experiments may have a bearing on the sparking in the brushes of dynamo machines?

Your power there of avoiding the spark might enable you to avoid the spark on the brush, which comes evidently from the same cause. In the paper in which Professor Hughes described these experiments to which you refer he indicated that there might be some difference in the metals that were used for brushes. There had been experiments in this country before then in that direction; but it seems to me it would be quite a prolific field of investigation to find out whether by alternating brushes, perhaps of iron and copper, you might not be able to eliminate the spark from the dynamo machine.

Mr. E. T. Birdsall—Dr. Moses speaks of sparking from the brushes of dynamos. It has been some time since we have seen much of that.

The Chairman—We have with us a gentleman from Boston, Mr. Hamilton, from whom we should be pleased to hear.

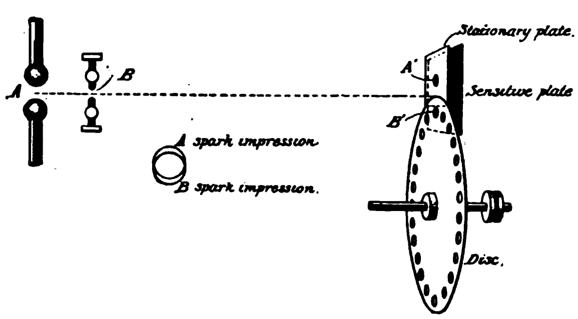
Mr. Leonidas Le Cenci Hamilton—I have been very much pleased to hear the paper which has been read. One question arises in my mind—whether or not the ghost, so-called, in the photograph might not have been caused by a difference in the revolution of that disc. It seems to me that the experiments, with no possibility, as I can understand it, of accuracy, as to velocity of revolution, might possibly result in this ghost filling the plate.

Mr. Acheson—I neglected to state the manner in which the disc was timed. I timed it always. Of course, I could not get an exact speed. These are not printed exactly like the negatives. While some of them exhibited a little or no ghost at all, others exhibited a length of as much as a tenth of an inch. Now, we know there is no difference in speed like that.

Mr. Hamilton—How did you control the speed?

Mr. Acheson—I had everything ready for the discharge of the jar and held that in waiting until I had the speed up, with my watch before me. I worked with a treadle so that I had perfect control of it and worked it up until I had a revolution of the band wheel of a certain value, of which my note book gives the record in each and every experiment.

Mr. Hamilton—The photographs were each separate, were they not? For instance, in No. 5 (page 53), A and B, were the photographs taken at different times?



MR. ACHESON'S APPARATUS.

Mr. Acheson—That A, B spot was made by one spark at the same instant of time. The spot A was produced through a stationary aperture, while the spot B was produced through the moving aperture in the disc. It was a question that I wanted to decide whether any vibration that might be introduced in the work would cause any movement of the outlines, and I always had the A spot for that object, so that I might have a means of comparison with the spot produced by the moving aperture. I am sorry that these are not an exact print of the negatives, but I presume we never will have them. I do not suppose that they could be reproduced exactly. Even if the plate is good the printing will disfigure it.

Mr. L. W. Serrell, Jr.—I would like to ask Mr. Acheson if he developed the negatives all at the same time, that is, with the same developer, and gave them all an equal length of time in developing. This ghost or tail of a comet is a vanishing thing, and if the development was applied at different lengths of time it would make a different depth to the negative and make a different length to the ghost or to the tail. I would like to know whether they were all developed at the same time.

Mr. Acheson—I am not a photographer by profession, and, in fact, I never did any photographing until I commenced this work. I bought my supplies in a store and used a small hand-book as a guide. Although I spoiled some plates, each and every one of them was developed separately, and it was all done after night. None of this work was done by daylight. Much of it was done in the neighborhood of midnight or later, and, as a rule, after considerable experience, I developed them until they ceased to show any increase.

Mr. Birdsall—In taking pictures on glass plates such as Mr. Atcheson took, although these probably do not exhibit that defect to any extent, a glass sensitive plate pointed at any bright object, and a picture taken of the bright object, it will always exhibit this halo, and taking a picture through a hole like that, if the source of light were not perpendicular to the surface of the plate, it would exhibit that halo on one side. If the spark was not far enough away from the surface of the plate, so that both the holes A and B were practically in a perpendicular line, that property which is called halation of plates, and which is avoided in the paper negatives—that property would introduce probably an appreciable error, as in taking pictures with say a 10-inch focus lens, we get a picture of the sun on a plate about one-quarter of an inch in diameter, and there will often be a half-inch of this halo around this image on the plate. If we take a picture of the sun through a large hole it would in all probability show more halation on one side than on the other, similar to these pictures, although that error may not be introduced in these.

Mr. Joseph Wetzler—There is one point that occurs to me in connection with figure 5 (page 52). Mr. Acheson remarked that when he applied an iron rod in that coil the spark was very much diminished. He attributed this at first to the magnetization, but when he inserted the copper he found the same diminution of spark. He then came to the conclusion that the retardation was due to the energy abstracted from the circuit by electric currents set up within the bar. It seems to me that that result of the equal action of the iron and the copper might have been predicted when we consider that it takes some time for iron to magnetize; in other words, the iron would not, as a rule, magnetize with a current of a static discharge on account of its great rapidity; that static discharge is practically instantaneous; while it takes some time for iron to magnetize, something in the neighborhood of one-hundredth of a second, if I remember rightly. We might, therefore, conclude that the effect was not due to magnetization of the iron, but was probably due to electric currents set up in the iron.

Mr. Acheson—I quite agree with Mr. Wetzler in his opinions; it is such as I finally formed.

Mr. Serrell brought up a question in regard to the production of the ghosts being due to the line of the ray of light not being perpendicular to the glass surface. At first I had some difficulty and thought I had achieved success before I had, owing to the fact that my two sparks and the hole through which they were taken were not in a direct line, and it caused a distinct overlapping of the outlines of the spark as produced in the spot, very distinct and sharp. At first I thought it was a difference of time between the two sparks; that the spark was a little back of A, which was what I wanted, and I was much pleased; but it was not the case; it was simply due to the fact that they were not in line.

Professor Geyer—I was unfortunate in not hearing the whole of this paper, and I am not sure that I fully grasped it. I hope I may be pardoned in asking a question for my own information—to what cause, Mr. Acheson, did you ascribe the ghost? I am not sure that I quite caught that.

Mr. Acheson—It is due to the oscillation of the current and the continuous charging and discharging of the condenser surfaces, which has to go through the space A, as illustrated in these figures, producing a spark continually diminishing in flow, and continuing for a certain length of time until the energy is expended in some manner. On the negatives you can see that the spark weakens and fades away until it actually disappears. You cannot give it a definite length. You cannot set an end to it. This is due to that gradual diminishing of the amount of energy which is oscillating backward and forward in the circuit.

Professor Geyer—I know of an analogous experiment which I think proves that the position you take is perfectly correct, and that it is not necessary to find photographic causes for the ghost. The experiment, I recollect, was one made by Professor Meyer, of the Stevens Institute, where a Leyden jar was discharged through the prongs of a tuning fork, at the end of which there was a little pointer which moved over a rotating cylinder blackened with lamp black. When the Leyden jar was discharged there was made on that blackened paper one great blotch where the lamp black was dissipated. At some distance further on, the cylinder rotating with uniform velocity, there was another blotch, and then there were three and four, and then there would be a moderate interval; then there would come a great group of them, and then another group, so that, taking the trouble to count them, there were actually several hundred of those discharges recorded, with no possibility of any photographic disturbance on this cylinder, showing that there were at least 700 of these oscillatory discharges.

Mr. Charles Cuttriss—I would like to ask Mr. Acheson a question in regard to these diagrams as taken from the negative. You will observe in both of them that there is a full light circle and then a tail. Now, I would ask if that was so on the photograph, or was it not a gradual broadening up without any abrupt line between the bright part and the other? It would appear to me as though there was at the first discharge a greater volume of light or a more intense passage of current just at that distance to photograph the true hole and show it across the table.

Mr. Acheson—If I understand the gentleman correctly he wants to know whether the outline of the aperture in the disc is clearly defined. It is, if that is the question. On the negatives it is clearly defined. You can trace perfectly all those outlines. I think that you are correct in assuming that the first discharge is vastly greater than any succeeding one. That outline is shown on the negative.

Mr. Allan V. Garratt—I have listened with a great deal of interest to this paper and discussion, and I cannot help wishing that before we go away we may get a few more facts in regard to these photographs, if possible, to clear up any possible doubt as to their character. I should like to ask Mr. Acheson if the plates were all of one make and of the same number?

Mr. Acheson—All of same make and all number 26.

Mr. Garratt—I understand they were developed, practically, until they would not develop any more. I have occasionally played with plates myself. I see no reason under those circumstances to suppose that the trail of light, which I think a photographer would not call a ghost, is not correct. I do not see any elements of error there. In regard to the speed of rotation, some of the trails are only half the length of the others. I do not know with what degree of regularity Mr. Acheson can revolve a sewing-machine wheel, but I should suppose that he would be able to eliminate an error of fifty per cent.; that is, if he worked it as hard as he could, and if he was in equally vigorous condition during all of his experiments, I see no reason to suppose that any considerable degree of error was introduced there.

I cannot help feeling, gentlemen, that this paper—the matter therein contained—is something that will lead to a good deal of discussion and investigation on this extremely interesting subject. I believe that it is one that we shall hear a good more of.

Mr. Birdsall—My suggestion in regard to the spot of lights showing the entire circle of the hole and then fading away, is that the first spark of the continued series of sparks which formed the discharge, might be the one which has the most energy in it in the form of light due to conditions of the air, such as burning the dust between the poles or anything like that, and the succeeding ones might have as much energy in them, although not so much of that energy in the form of light, but more in the form of heat.

Mr. Serrell—I would like to ask Mr. Acheson which way his wheel turned around, whether the tail was due to the wheel, gradually cutting off the light on the plate, and the spark being produced by duration, or whether the first bright spot was due to the first flash, and the wheel went in the direction of the tail.

Mr. Acheson—The aperture moved in the same direction in which the tail faded.

The Chairman—This certainly is a subject of interest in almost all branches of the electrical profession, particularly in the department with which I have been identified myself, where we find these antagonistic currents in our relays, in our cables and in our wires. It causes us a good deal of trouble to find just how they act and also to overcome their bad effects; particularly in relays where the signaling current passing through the various convolutions arouses this antagonistic current and causes relays to act very slowly. It changes the character of the signals entirely. I think probably, as suggested, in dynamo machines, this current has a great deal to do with almost every electrical apparatus. I do not see how you can avoid it.

If there are no further remarks to be made upon the subject the secretary has some matters which he wishes to bring to your attention.

The Secretary—Gentlemen, it gives me pleasure to announce that the next paper to be read before the Institute in the regular series will be by Lieutenant Jarvis Patten, a member of the Institute, on February 12th, entitled "On a New System of Multiplex Telegraphy," with illustrations. It is possible that during the present month an extra paper will be presented by Mr. F. L. Pope, on some recent work in the field of electro-metallurgy. He is engaged in the preparation of this paper now, but he is not certain about the time at his disposal, and it is barely possible that he may not have it in readiness, this month, but if it should be ready due notice will be given as usual.

Mr. Cuttriss—If the discussion on this paper is ended I would take pleasure in moving a vote of thanks to the author for one of the most able papers and showing the deepest insight, I think, into recent research, that we have had before us.

The motion was carried.

The Chairman—I have, therefore, very much pleasure in presenting Mr. Acheson with the unanimous thanks of the Institute for the able and interesting paper he has presented with so much pains and so much care and accuracy of experiment.

Mr. Acheson—I thank the Institute for this kindness in appreciating a little work.

Adjournment.

.... ANOTHER INDUCTIVE TELEGRAPH INVENTOR.—Rev. Balus Cade, of Wake Forest, North Carolina, has a device by which a telegram can be sent from a *morning* train, or from one *morning* train to another.—*Electrical Review*, N. Y. Why not from afternoon trains?

THE EDISON UP-TOWN STATIONS.—NEW YORK.

The beginning of service by the Edison Illuminating Company in the up-town districts of New York is a very noteworthy event in the progress of house-to-house electric lighting. It is of special interest, not only on account of the magnitude of the undertaking, but equally or more so from the thorough and magnificent manner in which the whole work has been designed and carried out.

After an investigation of the lighting in New York city, it was decided to lay out and construct generating stations and conductors for distribution of current, to supply the territory bounded by Seventeenth and Fifty-ninth streets and Third and Eighth avenues. The supply of motor service from the same stations and through the same conductors is included in the system. In addition to the two stations now substantially completed in 26th and 39th streets, a third in 53d street will soon be under construction. The station buildings are most substantial in construction and very elegant in appearance. In their interior plans they present striking novelties, the distribution of the machinery, boilers and engines, having been laid out on altogether new lines.

The Twenty-sixth street has a frontage of 56 feet and a depth of 98 feet 9 inches. The excavation for the foundations, cut out of solid rock, has a depth of fourteen feet below the street. The height of the building is about 90 feet. The two stations are substantially alike. There are a basement and four stories. In the basement the engines are located; on the first floor the dynamos; on the second floor, apparatus for handling ashes, and a general workshop; and on the third floor the boilers. The top floor is devoted to the storage of coal, tanks for water supply, and a commodious meter room.

The engine room contains 14 Armington and Sims' high-speed engines of 200 h. p., each belted to two dynamos on the next floor above. The 28 dynamos have each a capacity of 600 amperes and an initial E. M. F. of 140 volts. On the second floor a central space is fitted up as a general workshop and repair room. On each side of this space, next to the wall, are located the large horizontal smoke flues leading from the boilers above and extending along each side of the building to the rear and connecting with the smoke stacks. Between the smoke flues and the partition dividing off the workshop are the ash pits and the cars for handling ashes.

The Babcock & Wilcox water tube boilers are arranged in two batteries of seven on each side of the third floor.

A striking feature in the carefully worked out plans of the station house, is found in the arrangements for storing and handling coal. There are two large elevator shafts from the basement up to the roof. The elevators are balanced against each other, their cables winding and unwinding on the same drum, and operated by a double cylinder engine of ample capacity located in the basement. For each of the platforms there is an iron car capable of holding 1¼ tons of coal. Supported about midway between the floor and ceiling of the coal loft on the fourth floor are three car tracks, to the level of which the coal is hoisted in the car. When the load of coal arrives at the top of the elevator shaft, the car is shoved off on a weighing platform. The car is dumped by automatic apparatus at any point desired. In the meantime the other elevator with its empty car has descended and is receiving its load. Messrs. Crane Brothers supplied the elevators. Coal, from the loft, is delivered in front of the boilers through iron chutes.

Two large and one smaller Davidson pumps are placed in the vault under the basement.

The entire scheme of the up-town stations and service was carefully elaborated, with the view of employing the most advanced and best electrical and engineering methods of design and construction, by a special committee. The committee comprised Mr. E. H. Johnson, president of the Edison Electric Light Company; Mr. C. H. Coster, director of the Edison Electric Lght Company and of the Edison Electric Illuminating Company; Mr. John I. Beggs, vice-president and general manager of the Edison Electric Illuminating Company, of New York; Mr. C. E. Chinnock, the former general superintendent of the Edison Electric Illuminating Company, of New York. Mr. J. H. Vail, the general superintendent of the Edison Electric Light Company, was appointed chief engineer of the committee. Mr. Chas. E. Emory, M. E., was retained as consulting engineer, and Mr. Albert Buchman as the architect.

The result of their work as seen in the two solid, elegant and thoroughly equipped stations, testifies to the skill and good judgment of the committee, no less than to the broad and liberal views of the directors of the Edison Electric Illuminating Co. evinced in their large investment of capital in the work.

The distribution is to be by the three-wire system in the up-town district. About sixty miles of the well-known Edison tubes have already been laid underground in the up-town streets—making about 180 miles of conductors.

.... THREE classes of men have been required for the accomplishment of the greater triumphs of science; the investigators or discoverers of abstract and often apparently useless truths, teachers of all grades, and popularizers.—*Alpheus Hyatt.*

A RESTLESS PHILANTHROPIST.

We have been favored with a circular letter, reprinted below, by one of the fortunate recipients. It is rather too good to keep and will be sufficiently diverting without comment.

Designer of Apparatus for Special Purposes.
Contractor for Arc and Incandescent
Electric Lights and Steam-Power.

City Street Lights Tested and Compared with
Contract Requirements,
Complete Plants Erected for City Lighting.

HAROLD P. BROWN,
ELECTRICAL ENGINEER,
201 West 54th St., New York.

Dear Sir:—I address you on a matter of LIFE and DEATH which may personally concern you at any moment. Last spring alarmed at the large number of deaths caused by careless methods and criminal economy on the part of many electric lighting companies, I started a movement in favor of greater care for public safety. In a careful essay I tried to point out the sources of danger and to indicate means whereby arc lighting could be made safe. But there is no possible way of making safe the high-tension alternating current, which is now extensively used for incandescent lighting. At once representatives of the alternating current syndicates, which are both wealthy and unscrupulous, made vicious personal attacks upon me and put themselves upon record as claiming that their current was "absolutely harmless" and "perfectly safe" (see *Electrical World*, July 28). The only course open to me to maintain reputation was to demonstrate by experiment the exact death pressure in the continuous and the alternating currents; but to do this with scientific accuracy required apparatus which cannot be obtained at short notice in this country.

I therefore called upon MR. THOS. A. EDISON, whom I had never before met, and asked the loan of instruments for the purpose, which could not be obtained by me elsewhere. To my surprise Mr. Edison at once invited me to make the experiments at his private laboratory and placed all necessary apparatus at my disposal. The results proved beyond question that the alternating current would PRODUCE INSTANT DEATH at one-sixth the pressure used by the alternating current companies for electric lighting and pronounced by them "perfectly safe." (See inclosed report, Medico-Legal Society.)

Under the auspices of Dr. Cyrus Edson, of the BOARD OF HEALTH, I then made two public demonstrations at the School of Mines, Columbia College, which the alternating current people were invited to attend and were given opportunity to verify my measurements with their own instruments. This, of course, they failed to do, and in spite of the fact that their current has *killed and crippled for life* a large number of men, they still endeavored to deceive the public, objecting to my experiments because the subjects used "weighed less than a man and were therefore more easily killed." I then invited the committee of the Medico-Legal Society having in charge the determination of the BEST METHOD OF EXECUTING CONDEMNED CRIMINALS (under the N. Y. electrical execution law which goes into effect Jan. 1, 1889), to witness the killing, with the alternating current, of animals weighing as much or more than a man. This so impressed the committee with the death-dealing qualities of the alternating current that they drew up the inclosed report, recommending its adoption for EXECUTION PURPOSES at exactly the pressure used for "safe and harmless" electric lighting. At the society's meeting of Dec. 12, this report was *unanimously adopted* after the representatives of the alternating current companies had been given ample opportunity to defend their views.

Even this did not discomfit them, for Mr. Geo. Westinghouse, Jr., president of one of the alternating current companies, published on the 13th a letter upholding his high-tension alternating current as "less dangerous than the continuous." To test his sincerity in making so absurd a statement, I published on Dec. 18th the enclosed challenge which will explain itself. This has as yet received no acceptance.

Now, HOW DOES THIS AFFECT YOU? The special danger in the use of the high-tension alternating current lies in the fact that its physical effect on the nerves is many times greater than the continuous current with the same pressure, and the rapid alternations place the insulation of its conductors under a tremendous strain, similar in effect to that produced by what is known as "water hammer" in pipes. This strain causes *leakage to the ground* from the wires which I find upon careful measurement, is sufficient to kill or cripple any person standing on a damp place and touching either wire, and the danger increases in direct proportion to the length of the wire and the dampness of the day. That this danger is not imaginary is shown by over 15 deaths and a large number of serious injuries within the past year from this very cause, and many of these cases were *not* electric light employés. In every city having a large alternating current station many crippled pensioners can be found. The most serious cases of injury are those of a son of Professor Young, of Princeton College, who was paralyzed by stepping on a ground connection while touching an alternating current wire; and W. J. Bell, of St. Paul, whose nervous system was completely shattered by touching a guy wire on a District telegraph pole which happened to be in contact with a Westinghouse alternating current wire some distance away. In this case, the "insulation" of the alternating current wire was *apparently perfect*. It is not an uncommon thing for telephone and district telegraph apparatus to be burned by their wires coming in contact with the alternating current conductors; any person who then touches the telephone or call box runs a terrible risk. This BRINGS THE DANGER HOME TO ALL OF US.

What is the remedy? Simply a limitation of the pressure to 300 volts or less, which will then make the alternating current no more dangerous to the general public than the arc light wires, since in order to kill it would be necessary to grasp both wires. The leakage to ground would then be less than the pressure required to kill. The expense occasioned to the electric lighting companies by this reduction of pressure to SAFE LIMITS would be simply the cost of about *twice as much additional wire* as they now have in use, which would be insignificant in comparison with the good result thus obtained.

I therefore ask you as a public-spirited man, to oppose with all means in your power the extending of the high-tension alternating system in any city or town where you have influence; to lend me your aid in securing legislation which will keep this EXECUTIONER'S CURRENT out of our homes and streets, and prevent reckless corporations from saving their money AT THE EXPENSE OF THE LIVES OF THOSE DEAR TO YOU.

The killing of a little child in the streets of Philadelphia, on Dec. 17th, outweighs all possible considerations of "economy in first cost" so temptingly set forth by Mr. Westinghouse's company and others. I shall be glad at any time to send you printed matter on this subject or to *assist you in any way* against the encroachments of the executioner's current. In return I shall esteem it a favor to receive information of any deaths or injuries from electric lighting in your vicinity, or any "answers" to my arguments brought forward by my opponents.

Sincerely yours,
HAROLD P. BROWN.

ENGLISH COMMENT ON MR. BROWN.

The conflict between the continuous and the alternating systems has been renewed with increased vigor in the states. In a long letter to the New York *Times*, Mr. George Westinghouse, Jr., makes some sharp comments on the recent experiments of Mr. Harold P. Brown, at Edison's laboratory, Orange, N. J.; asserting that Mr. Harold P. Brown is not seeking for truth, but is looking after the imperiled interests of the Edison company. Mr. Westinghouse is not content that the alternating current system should be considered as safe as its rival, it is much safer; "the alternating current is less dangerous to life, from the fact that the momentary reversal of direction prevents decomposition of the tissues." To this onslaught, Mr. Harold P. Brown has replied by a challenge to a duel *à l'outrance*. Mr. Westinghouse is to take a current alternating 300 times a second through his body, and Mr. Brown will do likewise with a continuous current; the pressure is to begin at 100 volts and increase by 50 volts at a time; each contact is to be made for five seconds, and the battle is to go on until one or the other has cried enough. All this is, no doubt, excellent fooling, but has little or nothing to do with the question at issue, which is simply whether the dangers of high tension currents are so great and of such a nature as to warrant the enforcing of precautions which would practically amount to prohibition. This question, we take it, is satisfactorily answered by our own experience of alternating current distribution from the Grosvenor Gallery, as well as by the enormous and increasing growth of the Westinghouse company in America. Even Mr. Harold P. Brown, we should think, must at heart accept the deductions he would have us draw from his experiments with several reservations, in the face of such a remarkable manifestation of public favor.—*The Electrician* (London).

CONSOLIDATION OF ELECTRIC LIGHT COMPANIES.

The consolidation of the Westinghouse and United States companies, is an event of unusual importance in the electric lighting business. Until within a short time the manufacture of electric lighting apparatus, both arc and incandescent, was practically in the hands of six corporations, viz., the Brush, Edison, Thomson-Houston, Westinghouse, United States and Sawyer-Man companies. The Westinghouse company having leased the Sawyer-Man and assumed the control and management of the United States company, the number is now practically reduced to four. The new combination, however, now greatly exceeds either of the others in extent of manufacturing facilities, volume of business, and number of important patents owned.

The United States is the successor of the Weston Electric Light Co., which was organized July 7, 1877. It owns the inventions of Edward Weston, Moses G. Farmer, and other prominent inventors, which cover many early inventions relating to electric lighting. Some of these are of a fundamental character, especially those relating to dynamo machines, automatic regulation and incandescent lamps, not a few of which antedate even

the work of Mr. Edison in this field. Having been in active and extensive operation for 12 years it has several hundred plants in operation, besides a number of central stations. Its manufacturing business amounts to more than $1,000,000 per year, and includes dynamos, motors, fittings, fixtures, and arc and incandescent lamps. Its Newark factory has a capacity for making 5,000 incandescent lamps per day, and other material in proportion.

The Westinghouse company has, in a little over two years, taken the first rank in the incandescent lighting business, having sold 143 central station plants, having a total capacity of 250,000 16-candle incandescent lights in actual operation. It recently purchased the Waterhouse company, of Hartford, and has commenced the manufacture of arc lighting plants on that system, having now in hand an order for 1,200 arc lamps, and a corresponding outfit of dynamos for lighting the City of Pittsburgh. The combined capacity of the consolidated companies is equivalent to 15,000 incandescent lamps per day, or 4,500,000 lamps per year, and there is every indication that the capacity of the works will soon be fully tested. It is now preparing to manufacture Tesla motors in large quantities for use in connection with alternating stations.

STORAGE BATTERIES.

TEMPORARY INSTALLATIONS.

The storage battery is found to be a most convenient and effective means of providing electric illumination for special occasions—such as balls, dinners, and other large social entertainments—abundant and artistically arranged lights enable the decorator to enhance his effects to a surprising degree.

A particularly successful use of accumulators for this purpose was made on the occasion of the ball at Dr. Webb's city residence, January 11. The outfit was furnished and placed by the Electrical Accumulator Co.

The following is from the report of Mr. Geo. B. Prescott, Jr., electrician of the company.

"* * * The following are the main points in relation to the temporary installation of accumulators at Dr. Webb's ball on last Friday evening:—

"There were two series of 35 cells each of the Electrical Accumulator Co.'s "15 A" cells, which were connected in parallel and supplied current for 90 16 c. p. lamps, from 6 o'clock in the evening until 4 o'clock in the morning. These cells were charged at the company's works at Newark and carted to Dr. Webb's residence on the day of the ball, where they were placed in the basement. The lamps were used for the illumination of the ball-room and the banquet hall. In the former there were 60 lights which were suspended from the cornices and formed a border on four sides of the room. Beneath the lights was stretched a width of very thin transparent pongee silk which agreeably tempered the light and gave it a pink tinge. The ceiling and walls of this room are very handsomely frescoed, and the light illuminated the paintings so effectively that they displayed beauties that had not before been noticed by the family. In the dining hall there were 30 lights distributed in a somewhat similar manner, the lamps being enclosed in decorative globes, some of cut glass and others, opal, arranged uniformly between the carved panels of the wall. The effect in both rooms was magnificent, and no accident or hitch of any kind occurred."

THE TELEPHONE.

ST. LOUIS.—THE NEW TELEPHONE BUILDING.—The Bell Telephone Co. of Missouri will soon be the possessors of an extremely handsome building. Work will be commenced at once on the plans of Messrs. Shepley, Rutan & Coolidge, architects, of Boston, whose design was chosen from several competing plans. The building is to be located on the southeast corner of Tenth and Olive streets. The site is 50 feet on Olive street by 109 feet on Tenth street. The building is to be seven stories high, and fireproof throughout. It will present a very striking and solid appearance. The cost will be about $125,000. The intention is to rent the first five stories and half of the sixth. The executive offices of the telephone company will occupy the west half of the sixth floor, the elevator coming up from the rear on the Tenth street side. The seventh floor will be occupied exclusively by the telephone operating room.

ELECTRIC LIGHT AND POWER.

ST. LOUIS.—The four electric light companies doing business in this city were consolidated to-day. The companies are the Brush, the Thomson-Houston, the Metropolitan Light and the Western Light Association. The stockholders of the Brush association, it is understood, have agreed to accept Thomson-Houston stock of par value, $100 for Brush Electric Association stock, share for share, and turn over the entire stock of their company, which would, of course, carry that company's plant, wires, franchises and business. The Thomson-Houston stock is worth probably $125, and has paid 2½ per cent. per month for some time. The terms of the deal with the Western are not known on the street further than that some stock and some cash will be given for the Western plant, franchises and business, and the Chicago people agree to keep out of St. Louis. The same terms have been accepted by the Metropolitan company. D. R. Powell, president of the Thomson-Houston, says the combination is not a trust, but that his company has purchased the other three.—*Press despatch*, January 7.

MORE ALTERNATING TRANSFORMER SYSTEMS.—It is learned from an authoritative source that the Brush Electric Co. is about to put a new alternating 2,000 volt transformer system on the market. This system is said to resemble very much the alternating system of the Anglo-American Brush corporation of London, brought out last summer by its electrician, Mr. Mordey. The Mordey alternating dynamo belongs to the type which has a stationary armature, with one internal field coil and large iron keepers revolving.

It is also learned that the Zipernowski-Deri system is soon to be introduced in the United States. Ganz & Co., of Budapest, the owners of the system, several years ago made an agreement with a leading American company, which is an advocate of the direct current incandescent system. This company, it is said, has never sold, and in fact, never tried to sell, a Zipernowski-Deri outfit, and thus practically shut the system out of the country, besides breaking the spirit of its agreement. At least Ganz & Co., a firm of enormous capital, whose electrical department represents only a fraction of their business, seem to have come to this conclusion. They are now ready, it is asserted, to negotiate or have already reached an agreement with an American company for the purpose of introducing their system in the United States.—*Western Electrician.*

A COAL cutter is run by an electric motor in the T. C. Heimes colliery near Osceola, Clearfield county, Pa. It is a 10 h. p. Sprague; is mounted on a truck running upon the rail-track of the mine. It is wheeled to any desired point, and connected to the cutter by a tarred hempen rope running over sheaves with V-shaped grooves, at a distance of about 30 feet.

Foreign.

France.—THE PARIS MUNICIPAL ELECTRIC LIGHT STATION.—The commissioners nominated to decide between the tenders for the steam and electric plant required in the central station have published their decision, which is to the following effect: The order for the boilers was given to the Belleville company, whilst that for the engines is divided between two firms—Messrs. Wehyer and Richmond, who supply three triple expansion engines of 140 h. p., and Messrs. Lecouteux & Garnier, who supply three single cylinder engines of 170 h. p. The dynamos are divided between the French Edison company, who supply six machines each, capable of an output of 400 amperes at 110 volts, and the agent of Mr. Ferranti, who supplies three Ferranti dynamos each of 113 kilo-watts capacity.

MANUFACTURING AND TRADE NOTES.

THE HILL CLUTCH WORKS, Eastern office, 18 Cortlandt street. New York, report that they have closed the contract with the Mt. Morris Electric Light Co., of New York, for the complete equipment of their large new station with everything in the line of power transmission machinery, friction clutches, etc. This station when equipped will be one of the finest in the country. At the start it will have a capacity of 2,000 h. p.

The same concern also report that they have just closed a contract with the United Electric Light Co., of Springfield, Mass., for the complete equipment of their station with friction clutches and everthing in the line of power transmission machinery. The Clutch Works designed this station, and they say when it is equipped it will be a fair rival, in point of fine machinery and workmanship, to their large plants in St. Paul and Minneapolis, Minn., which are considered in the west to be among the most complete and economical plants yet installed.

SPRAGUE MOTORS.—Mr. H. O. Woodruff, agent, reports the installation in Des Moines, Iowa, during the year 1888 of 18 Sprague motors, as follows: Iowa Printing Co., 20 h. p.; Leader Printing Co., 15 h. p.; Iowa State Register, 10 h. p.; Homestead Co., 5 h. p.; Western Lithograph Co. 5 h. p.; Cheshire Bros., Printers, 3 h. p.; Plymouth Congregational Church, 1 h. p., and 11 smaller ones for a variety of manufacturing and domestic uses.

THE WRIGHT ELECTRICAL ENGINEERING CO., of Boston, Mass., has been organized as a contracting and construction company. Mr. Alex. P. Wright, well known as superintendent of the Springfield, Mass. central station, and from his still earlier work as an old-time telegrapher is at the head of the enterprise. The company will enter largely in central station and railway work.

MR. W. L. ADAMS, formerly junior partner of Dickerman, Adams & Co., of Boston, agents for the Eddy motor for the New England states, has sold his interest in that firm and will engage in business for himself. Mr. Dickerman continues the firm's business.

MR. F. E. PETTINGELL, of Boston, has now associated with him Mr. Andrews, as junior partner, the firm name standing, Pettingell, Andrews & Co.

THE JOHNSON ELECTRIC CO., 14 Mt. Washington ave., Boston, Mass., has recently been incorporated. The company will manufacture a secondary battery of Mr. Johnson's invention.

THE ADVANCE ELECTRIC CO., 848 Congress street, Boston, have begun the manufacture of the Ward and Sloan battery. This company show the results of tests over the signature of Professor Dolbear, which are surprising for primary batteries.

THE WESTERN ENGINEERING CO.—The following is from the Kearney (Neb.) *Hub*, of January 5. :—"Negotiations have been carried on for some time past, and the contract has been closed, for the Western Engineering Co. of Lincoln, Nebraska, to remove to Kearney. The capital stock of the company has been increased to one hundred thousand dollars and stock all taken. The Western Engineering Co. put the electric plant in this city, and has many contracts throughout our own and adjoining states for other work. It will be a corporation of a high order, employing in its various divisions many hands. The fact is that Kearney is to become the electrical centre of the west."

Messrs. D. C. Jackson and J. G. White, who went west some two years ago from Cornell University, are at the head of this successful company.

THE CALIFORNIA ELECTRICAL WORKS, San Francisco, Cal., we are informed, have recently been appointed agents on the Pacific coast for the "Okonite" wires and cables for aerial, submarine, and underground use, manufactured by the Okonite Company, New York. This company report a large business in these specialties throughout the west.

NEW INCORPORATIONS.

Citizens' Electric Co., of Dudley and Oxford, Mass. Capital, $10,000.

Citizens' Electric Light Co., Webster, Mass., John W. Dobble and others. Capital, $10,000.

Grove Electric Light and Power Co., St. Joseph, Mo. Capital, $1,000,000.

American Electric Railroad Co., Chicago, Ills., H. Henry and others. Capital, $1,000,000.

Calkin Electric Co., St. Johns, N. B., Jeremiah Calkin and others. Capital, $150,000.

Hyde Park District Telegraph and Electric Co., Hyde Park, Ills., James Crape and others. Capital, $10,000.

Perkins Lamp and Electrical Supply Co., Chicago, Ills. Capital, $250,000.

Phœnix Electric Fire Escape Co., Chicago, Ills. William S. Bates and others. Capital, $130,000.

American Heat, Power and Light Co., Chicago, Ills., Jesse Cox and others. Capital, $100,000.

People's Eléctric Light and Power Co., Mount Vernon, N. Y., W. A. Armstrong and others. Capital, $100,000.

Riverton, Palmyra, Mount Holly Electric Light, Power and Heating Co., Mount Holly, New York. Capital, $50,000.

Merchants' Electric Light and Power Co., Birmingham, Ala. Capital, $20,000.

Eighth Street Electric Light Co., Philadelphia, Penn. Capital, $10,000.

Wisconsin Storage Battery Co., Milwaukee, Wis., DeWitt Davis and other. Capital, $10,000.

Continental Dynamo Co., Newark, N. J., Charles Schumacher and others. Capital, $20,000.

West Jersey Electric Light, Power and Heating Co., Camden, N. J., G. Harvey Knight and others. Capital, $25,000.

Joliet Light, Power and Transit Co., Joliet, Ills., Lewis E. Ingalls and others. Capital, $300,000.

National Electric Light and Motor Co., Victoria, B. C. Capital, $100,000.

Rhodes and Kesse Electrical Co., Los Angeles, Cal., S. J. Kesse and others. Capital, $10,000.

Middleborough Electric Light and Power Co., Middleborough, Mass., Wilbur A. Stiles and others. Capital, $25,000.

Savannah Electrical Co., Savannah, Ga., Herman Myers and others. Capital, $50,000.

Edison Light and Power Co., Portsmouth, Va., H. L. Maynard and others. Capital, $25,000.

Fort Collins Electric Co., Denver, Col., William B. Miner and others. Capital, $50,000.

Freeman Dynamo Electric Motor Co., 89 Liberty St., New York, N. Denison Morgan and others. Capital, $250,000.

St. Louis Electric Light and Power Co., S. M. Dodd and others. Capital, $600,000.

Citizens' Electric Co., Worcester, Mass. Capital, $10,000.

New Ulm Electric Lighting Co., New Ulm, Minn., M. Mullen and others. Capital, $25,000.

Monroe Electric Light and Power Co., Monroe, La. Capital, $25,000.

West Duluth Light and Power Co., West Duluth, Minn., W. T. Tanner and others. Capital, $35,000.

Western Electric Light Co., Milwaukee, Wis., Henry C. Payne and others. Capital, $100,000.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Allegheny, Pa	Observatory Hill Pass. Ry. Co	3.7	6	Bentley-Knight.
Ansonia, Conn.	Derby Horse Ry. Co	4	3	Van Depoele.
Appleton, Wis.	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	12	Daft.
Asheville, N. C	Asheville Street Railway	3	4	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Binghamton, N. Y	Washington St., Asylum & Park R. R	4.5	8	Van Depoele.
Boston, Mass	West End St. Ry. Co., Brookline Branch	12	20	Sprague.
Brockton, Mass	East Side Street Ry. Co	4.5	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	5	3	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	3	Daft.
Cleveland, Ohio	East Cleveland Railroad Co.	23.5	16	Sprague.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenport Central Street Railway Co	3.5	8	Sprague.
Danville, Va	Danville St. C. Co	2	4	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co	8.5	12	Van Depoele.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	7.5	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Fort Gratiot, Mich	Gratiot Electric Railway	1.75	2	Van Depoele.
Harrisburg, Pa	East Harrisburg Pass. Ry. Co	4.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	2	Sprague.
Ithaca, N. Y.	Ithaca Street Railway Co.	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind	Lafayette Street Ry. Co	2.25	8	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angelos, Cal	Los Angelos Elec. Ry. Co.	5	4	Daft.
Lynn, Mass	Lynn & Boston St. Ry. Co.	2.25	2	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co	9	12	Thomson-Houston.
Pittsburgh, Pa	Pittsburgh, Knoxville & St. Clair St. Railway	2.25		Daft.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Reading, Pa	Reading & Black Bear Ry.	1.5	2	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Richmond, Va	The Richmond Union Pass. Railway Co	13	40	Sprague.
Salem, Mass	Naumkeag Street Ry. Co.	1.75	6	Sprague.
San Diego, Cal	San Diego Street Ry Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
St. Catherine's, Ont	St. Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	9.75	13	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	5	10	Sprague.
Scranton, Pa	The People's Street Ry	10	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	4.5	10	Thomson-Houston.
Scranton, Pa	Nayang Cross-Town Ry	3	4	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Syracuse, N. Y	Third Ward Ry. Co	4	8	Thomson-Houston.
Washington, D. C	Eckington & Soldiers' Home Electric Railway Co	2.7	3	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	10	Van Depoele.
Wichita, Kan	Riverside & Suburban Ry. Co	7	8	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	3.6	7	Sprague.
Wilmington, Del	Wilmington City Ry. Co	6.5	13	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	1.5	2	Van Depoele.

Total—Roads 58
" Miles 308
" Motor Cars 424

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System
Alliance, Ohio	Alliance St. Ry. Co	2	3	Thomson-Houston.
Atlanta, Ga	Atlanta & Edgewood St. Ry. Co			Thomson-Houston.
Atlantic City, N. J	Pennsylvania R. R. Co	5	6	Sprague.
Bangor, Me	Bangor Street Railway Co.	5	4	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets			Bentley-Knight.
Boston, Mass	West End St Ry. Co., Harvard Square Branch	14	20	Thomson-Houston.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cincinnati, O	Cinc. and Inclined Plane Ry	6.5	20	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Erie, Pa	Erie City Pass. R. R. Co	3.5	20	Sprague.
Hudson, N. Y	Hudson St. Ry. Co	2.5	3	Thomson-Houston.
Lincoln, Neb	Lincoln Cable Ry. Co	5	10	Storage Batteries.
Louisville, Ky	Central Pass. R. R. Co		10	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co.	69.5	8	Sprague.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3.6		Thomson-Houston.
New York, N. Y.	North & East River Ry. Co.	3	20	Bentley Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.

Constructing or Under Contract.—(*Continued.*)

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Ontario, Cal.	Ontario & San Antonio Heights Ry. Co.	8	4	Daft.
Ottawa, Ill.		6	8	Thomson-Houston.
Port Chester, N. Y.	P. C. & Rye Beach Street Railway Co.	3	5	Daft.
Richmond, Va.	Richmond City Ry. Co.	7.5	50	Sprague.
St. Louis, Mo.	Lindell Railway Co.		1	Julien.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Street Ry. Co.	4	6	Sprague.
Seattle, Wash. Ter.	Seattle Electric Railway and Power Co.	5	5	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Southington, Conn.		2.2		Thomson-Houston.
Springfield, Mo.		2		Fisher.
Steubenville, Ohio	Steubenville Elec. Ry. Co.	2 5	10	Sprague.
Tacoma, Wash. Ter.	Tacoma Street Railway	5	4	Sprague.
Topeka, Kan.		14	30	Thomson-Houston.
Worcester, Mass.	Worcester & Shrewsbury	2.7		Daft.

Total—Roads............ 33

Notes.

ATLANTIC CITY, N. J.—The Pennsylvania Railroad Co. have closed a contract with the Sprague company for the electric equipment of their system of street railway at Atlantic City. Before adopting electric traction for their street cars the company caused a careful examination of the subject to be made by their engineer and experts. The managers of the Sprague Electric Motor and Railway Co. may justly congratulate themselves upon securing the contract.

BOSTON, MASS.—The Sprague Electric Railway, at Boston, which extends from the centre of the city at Park square to Brookline, and is a part of the West End Electric Railway, is now in practical operation, and is carrying a large number of passengers. The cars run easily and are under complete and perfect control, and respond readily in changing the speed to the different movements of the electric switch on the front platform moved by the operator. These operators are not skilled electricians, but for the most part street-car drivers, who have learned the method of operating the electric car after a few hours practice, and who express the opinion universally that it is far easier and more pleasant work than driving horses. The road has been already visited by a large number of street railway men from the neighborhood, and who have appeared to be much pleased with the neatness and unobstructiveness of the overhead system, and general look of stability and reliability of the entire road.

THE THOMSON-HOUSTON ELECTRIC CO., on November 29th, started to equip the Cambridge Division of the West End street railway, of Boston, running from Bowdoin square, via Cambridge street, West Boston Bridge, Main street, to Harvard square, Cambridge, three miles, and thence via North avenue to Arlington, four miles. About six miles of this line is double track and paved.

As the season was so far advanced it was first thought advisable to equip the line as far as Harvard square, and accordingly the rail connections were made from Harvard square to Bowdoin square, and back. This work was completed Dec. 3d. In view of the fact that the cars on this division of the West End street railway run on a headway of less than two minutes, it will be seen that remarkably good time was made by the Thomson-Houston company in removing the paving and drilling and connecting the rails without interrupting the traffic. The work of connecting the rails on North avenue is also about done. The poles used in equipping this line are made of lengths of strong iron pipe firmly shrunk together and are very neat and unobtrusive. There are three styles of these poles, it being deemed advisable to use a stronger one on the curves than was used on the straight stretches; 300 have been used from Harvard to Bowdoin square. They are set in crushed rock and cement.

The cross suspension method is to be used the entire length of the line. The cross wires from which the trolley wires hang have been stretched, and are in position from Harvard to Bowdoin squares.

The overhead trolley wires are now being placed in position. In order not to interfere with the operation of the cars during this work, a large platform staging is used, which permits passage of the cars underneath it. In connection with the work of equipping the line it may be said that the Thomson-Houston company has had to cope with several difficulties which would not enter into the construction of other lines in this city, and in the overcoming of which no little engineering skill has been employed. One of these points has been the drawbridge over which the two railway tracks run. Owing to its peculiar construction and situation, it has been found necessary, in order to effectually connect the wires, to design a special switch.

At the grade crossing of the Boston & Albany Railroad, in order to avoid raising the trolley wires above the gate, an automatic device will be employed in connection with the gates to prevent interference with the trolley wires. Twenty cars are to be equipped out of those now running on the road, three being fitted up at a time. The work on these is now in progress.

In regard to the power station, it is proposed at present to utilize the station of the Cambridge Electric Light Co., and place therein five 80 h. p. generators and complete switch-board for operating the same. The steam plant is already being placed in the station, and work of setting up the generators has been begun.

When the Thomson-Houston company completes their present contract with the West End street railway, 20 cars will be running from Bowdoin square to Arlington, each of which cars will have sufficient power to tow an additional car. All cars will be lighted with electric lights and equipped with head lights.

DAVENPORT, IA.—The electric railway installed by the Sprague company, has now been in operation over a month, and the president and directors of the road express themselves well pleased with the service. The officers of the road gave a striking proof of their confidence in their electrical outfit by advertising for sale all the horses owned by the company on the date of opening the road. Through the blizzard of Jan. 9th, which created so much disturbance along the Mississippi valley, and which snowed in a number of towns, stopping travel, delaying freight, and otherwise interrupting business, the Davenport electric railway kept on running without missing a trip, or any delay, although the road has a grade from 7¼ to 8 per cent., 1,600 feet long, upon one portion of its line, and several other grades of 6 per cent. with sharp curves.

HARRISBURG, PA.—The managers of the East Harrisburg Street Passenger Railway, operating the Sprague system, are so well satisfied with the practical and financial success of their electric plant that they have ordered an additional number of motor cars.

WASHINGTON, D. C.—The Thomson-Houston road of the Eckington & Soldiers' Home Railway, has been in operation since the latter part of October, and thus far without a hitch of any kind which can be laid to the electrical apparatus. The patronage of the road has increased to such an extent that it has been necessary to double the car capacity. Each motor car now tows an additional car, both of which are filled to their utmost capacity at every trip. The road is considered one of the finest which has been built in the United States, and reflects the utmost credit upon the Thomson-Houston company.

THE THOMSON-HOUSTON ELECTRIC CO. has recently closed a contract with the McGavock & Mt. Vernon street railway of Nashville, Tenn., for the equipment of a part of its road. The length of the line is 3.07 miles, of which 2.30 is double track, and .77 single, making a total length of single track 5.37 miles. There are seven curves on the line and numerous grades, the maximum being 5¼%. There will be six cars, each 16 feet in length, and capable of carrying 75 passengers, and equipped with two 10 h. p. Thomson-Houston motors. The overhead system will be used. Electricity will not be used on the entire line at present, but only upon a loop from Cherry street around by the Public square, back to the stables. The time now consumed by a car making this trip is 70 minutes. The electric cars will make this trip in 30 minutes. The consideration of saving one-half of the time, is a material one for both the company and the patrons of the road. Eight cars are now used on this division, and as the motor cars will be twice as fast, only four of them would be needed, but inasmuch as the company excepts an increased traffic the six cars will be put on as soon as ready. The city council, some weeks ago, granted a right to exchange animal for electric power to all the street railway companies, and if this road prove as successful as other roads operating this system, the remaining branches of the McGavock & Mt. Vernon road will be equipped, and it will, in all probability, be adopted by the East Nashville and South Nashville companies. The company has also closed a contract for the equipment of two miles of single track at Southington, Conn. The overhead line is all completed except on the curves, which are now being put in. The bracket method of suspension is employed except on the curves, where the cross suspension is used. The cars will be operated, each being equipped with two 10 h. p. Thomson-Houston motors.

LEGAL NOTES.

A DECISION AFFECTING THE RELATIONS OF DOMESTIC TO FOREIGN PATENTS.

SUPREME COURT OF THE UNITED STATES.

THE BATE REFRIGERATING COMPANY APPELLANT, *vs.* GEORGE H. HAMMOND & COMPANY.

Appeal from the Circuit Court of the United States for the District of Massachusetts.

Mr. Justice BLATCHFORD delivered the opinion of the Court, January 21st, as follows :—

This is a suit in equity, brought in the Circuit Court of the United States for the District of Massachusetts, December 16, 1886, by the Bate Refrigerating Company, a New York corpora-

tion, against George H. Hammond & Company, a Michigan corporation, founded on the alleged infringement of Letters Patent No. 197,314, granted to John J. Bate, November 20, 1877, for the term of seventeen years from that day, on an application filed December 1, 1876, for an "improvement in processes for preserving meats during transportation and storage."

The plaintiff is the assignee of the patent. The bill alleges infringement, within the District of Massachusetts and elsewhere in the United States, by the making, using and vending of the patented process, and alleges that the defendant has been engaged in the business of shipping fresh meat from the port of Boston to ports in Great Britain, by means of the process claimed in the patent. The claim is as follows: "The herein described process of preserving meat during transportation and storage, by enveloping the same in a covering of fibrous or woven material, and subjecting it when thus enveloped to the continuous action of a current of air of suitably low and regulated temperature, substantially as and for the purpose set forth."

The defendant filed a plea, setting up, among other things, that, on the 9th of January, 1877, letters patent of the Dominion of Canada, No. 6,938, for the same invention as that described and claimed in No. 197,314, were granted to the same John J. Bate, for the term of five years from the 9th of January, 1877; that after No. 197,314 had expired, at the end of the term of five years for which such Canadian patent was granted, the Circuit Court of the United States for the District of New Jersey, upon being advised of the grant of such Canadian patent, vacated and set aside an injunction which it had theretofore granted, by an interlocutory decree made in a suit in equity founded on No. 197,314, brought by the Bate Refrigerating Company against Benjamin W. Gillett and others; that thereafter Bate and the Bate Refrigerating Company procured the rendition of a judgment by the Superior Court for Lower Canada, declaring the Canadian patent to have been void *ab initio*, and vacating it and setting it aside; that such judgment of the Superior Court for Lower Canada being brought to the attention of the Circuit Court of the United States for the District of New Jersey, that Court reinstated said injunction; and that afterwards the Superior Court for Lower Canada, in a suit brought by Sir Alexander Campbell, Minister of Justice and Attorney-General for the Dominion of Canada, against Bate and the Bate Refrigerating Company and others, adjudged that its said prior judgment had been "arrived at through the fraud to the law and collusion" of Bate, the Bate Refrigerating Company, and another person, "deceiving the Attorney-General, the advocates, and the Court, employing and paying counsel on both sides, as well, seemingly, against themselves as on their apparent behalf," and revoked and annulled its said prior judgment. The plea concluded by averring that No. 197,314 expired on the 9th of January, 1882, and that the Circuit Court, sitting as a Court of Equity, had no jurisdiction to hear and determine an action in equity for the infringement of the patent.

The bill was then amended by averring that the application for the Canadian patent was not made until December 19, 1876, while the application for No. 197,314 was made December 1, 1876, and that the Canadian patent was not actually or legally issued until on or about June 26, 1878, on or about which date a model of the invention, as required by law, was filed in the Canadian Patent Office. The amendment to the bill also set forth the two judgments of the Superior Court for Lower Canada, and averred that by virtue of an act of the parliament of the Dominion of Canada, assented to May 25, 1883 (46 *Victoria, chap.* 19), the original term of the Canadian patent was actually fifteen years, instead of five years, and it would not terminate before the 9th of January, 1892.

Subsequently the defendant filed an answer to the bill, setting up among other defenses, want of novelty in the patented invention, but not denying that it had used the invention subsequently to the granting of the patent, and also setting up the granting of the Canadian patent for five years from January 9, 1877; that No. 197,314 was void, because it was issued for seventeen years, and its term was not limited by the Commissioner of Patents to five years from January 9, 1877; that the Canadian application was not made until after the application for No. 197,-314 was filed; that Bate did not file a model in the Canadian Patent Office until after the grant of the Canadian patent, and that the Canadian patent was actually patented to Bate on the 9th of January, 1877, and took effect on that date, although not actually delivered to the patentee until after the filing of the model. It also sets forth the two Canadian judgments, and avers that, on the 30th of November, 1881, Bate made a petition to the Commissioners of Patents for Canada, for the extension of No. 6,938, in which he averred that on the 9th of January, 1877, he "obtained a patent for the period of five years from the said date, for new and useful improvements on apparatus and process for ventilation, refrigeration, &c," and that he was the holder of that patent in trust for the Bate Refrigerating Company, and prayed that it might be extended "for another period of ten years;" that, on the filing of that petition, an extension of the patent was granted on December 12, 1881, "for a second period of five years" from January 9, 1882; that a further extension of the patent was granted December 13, 1881, "for a third period of five years" from January 9, 1887; that the plaintiff is thereby estopped from denying the fact that No. 6,938 was legally granted January 9, 1877, for a period of five years; that by virtue of the act of 46 *Victoria Chap.* 19, the original term for which No. 6,938 was granted was not 15 years instead of five years; that said act can have no effect on the duration of No. 197,314; that by reason of the prior patenting of the invention by Bate in Canada for five years from January 9, 1877, No. 197,314, if valid at all, expired on January 9, 1882; and that, therefore, this court, sitting in equity, has no jurisdiction to hear and determine an action for its infringement.

Without the filing of any replication to this answer the parties entered into a written stipulation, setting forth as follows: "Whereas, the answer of the defendant corporation in this cause sets up, in addition to other defenses, that the patent on which this suit is brought, being No. 197,314, granted to John J. Bate, complainant's assignor and president, on the twentieth day of November, A. D., 1877, expired on the ninth day of January, A. D. 1882, by reason of the prior grant to said John J. Bate of a patent in the Dominion of Canada for the same invention, and prays the same benefit of said defense as if the same had been pleaded to the bill of complaint; and, whereas, both parties desire to have said matter of defense argued and decided without incurring the great expense of taking testimony necessary to present for final hearing all the defenses raised in said answer: It is, therefore, stipulated and agreed by and between the parties that the defense above named shall be submitted to the court, as on plea set down for argument, upon the following agreed state of facts." The facts so agreed to were substantially as follows:—

1. The patent in suit, No. 197,314, was granted to John J. Bate on November 20, 1877, and the application therefor was filed in the United States Patent Office, December 1, 1876; and said patent was assigned to complainant before this suit was brought, the said Bate being a citizen of the United States at the time of said application, and the said invention having been made and reduced to practice by him therein.

2. On December 19, 1876, said John J. Bate filed in the Patent Office of the Dominion of Canada an application for a patent for improvements in apparatus and processes for ventilation, refrigeration, etc., including therein as one feature, the process described and claimed in said patent No. 197,314.

3. In pursuance of said application the Commissioner of Patents for the Dominion of Canada caused letters patent of the Dominion of Canada, No. 6,938, for the invention set forth in said application, and granted to said John J. Bate, his executors, administrators and assigns, the exclusive right, privilege and liberty of making, constructing, using and vending to others to be used, the said invention, to be signed and sealed with the seal of the Patent Office on January 9, 1877, and to be registered on January 11, 1877, and that the period of said grant expressed in said patent was five years from and after January 9, 1877.

4. On January 12, 1877, said Commissioner of Patents called upon said John J. Bate to furnish to the Patent Office a model of his said invention, and such model was furnished by said Bate on June 26, 1878, on which day said patent No. 6,938 was mailed to said John J. Bate.

5. On December 5, 1881, said John J. Bate filed a petition in the Canada Patent Office, setting forth "that on the 9th day of January, A. D. 1877, your petitioner obtained a patent for the period of five years from the said date for new and useful improvements on apparatus and process for ventilation, refrigeration, etc.; that he is the holder of the said patent in trust for the 'Bate Refrigerating Company,' and therefore prays that it may be extended for another period of ten years."

6. On December 12, 1881, said patent No. 6,938 was extended for five years from January 9, 1882, under renewal No. 13,812, and on December 13, 1881, said patent was further extended for five years from January 9, 1877, under renewal No. 13,818, in pursuance of the above-named petition.

7. On or about July 9, 1883, and June 30, 1886, the Superior Court for Lower Canada rendered two judgments affecting said Canada patent, to the purport set forth in the plea and the answer.

The stipulation further provided, that, if the decision of the Circuit Court should be in favor of the plaintiff, it should have a reasonable time thereafter to file a replication to the answer, and the cause should proceed in the ordinary manner; that, if the Circuit Court should decide the cause in favor of the defendant, a decree should be entered dismissing the bill, so that the plaintiff might take an appeal therefrom to the Supreme Court of the United States; and that, if the Circuit Court should decide the cause in favor of the defendant, and the Supreme Court of the United States should, on appeal reverse that decision, the defendant should have a right to proceed in the Circuit Court, under its answer, as to all defenses set up therein except the one mentioned in the stipulation, as it might have proceeded if the stipulation had not been made.

The cause was heard on the pleadings and stipulation, and the Circuit Court entered a decree dismissing the bill, from which decree the plaintiff has appealed to this Court. The Circuit Court gave no opinion on the merits of the case, but in deciding it followed, as it stated, the decision of the Circuit Court of the

United States for the District of New Jersey, held by Mr. Justice Bradley, in August, 1887, made in the case of *Bate Refrigerating Co. vs. Gillett* (31 *Fed. Rep.*, 809).

The questions discussed at the bar arise under Section 4,887 of the Revised Statutes, which is as follows: "No person shall be debarred from receiving a patent for his invention or discovery, nor shall any patent be declared invalid, by reason of its having been first patented or caused to be patented in a foreign country, unless the same has been introduced into public use in the United States for more than two years prior to the application. But every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one, at the same time with the one having the shortest term, and in no case shall it be in force for more than seventeen years."

Two propositions as to the construction of this section are contended for by the appellant: (1) That the words "first patented or caused to be patented in a foreign country" do not mean "first patented or caused to be patented" before the issuing, or granting, or date, of the United States patent, but mean "first patented or caused to be patented" before the date of the application for the United States patent; (2) that the declaration of the section, that "every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one at the same time with the one having the shortest term," does not mean that the patent so granted shall expire at the same time with the term to which the foreign patent was in fact limited at the time the United States patent was granted; but that it means that it shall expire when the foreign patent expires, without reference to the limitation of the term of such foreign patent in actual force at the time the United States patent was granted.

We do not find it necessary to consider the first of these questions, because we are of opinion that the proper construction of Section 4887, upon the second question is, that the patent in the present case does not expire before January 9, 1892, the time when the Canadian patent, No. 6938, will expire.

The Canadian patent was extended for the two periods of five years each, under the provisions of Section 17 of the Canadian Act assented to June 14th, 1872 (35 *Victoria, Chap.* 26), which was in force when the United States patent, No. 197,314 was applied for and granted, and which read as follows: "17. Patents of invention issued by the Patent Office shall be valid for a period of five, ten, or fifteen years, at the option of the applicant, but at or before the expiration of the said five or ten years the holder thereof may obtain an extension of the patent for another period of five years, and after those second five years may obtain a further extension for another period of five years, not in any case to exceed a total period of fifteen years in all; and the instrument delivered by the Patent Office for such extension of time shall be in the form which may be from time to time adopted, to be attached, with reference to the patent, and under the signature of the Commissioner or of any other member of the Privy Council in the case of the absence of the Commissioner."

This statute appears to have been strictly complied with in the present case. The Canadian patent, No. 6938, ran, on its face, for five years from January 9, 1877, and, prior to the expiration of that time, and on the 5th of December, 1881, Bate applied for its extension for ten years; and it was, before the five years expired, and on the 12th of December, 1881, extended for five years from January 9, 1882, and on December 13th, 1881, for five years from January 9, 1887. The Canadian patent, therefore, has never ceased to exist, but has been in force continuously from January 9, 1877. It was in force when No. 197,314 was issued; and it has, by virtue of a Canadian statute, in force when the application for No. 197,314 was filed, continued to be in force at all times since the latter patent was granted. This is true, although the Canadian patent, No. 6938, as originally granted, stated on its face that it was granted "for the period of five years" from January 9, 1877; and although the instrument granting the first extension of five years states that it is granted "for another period of five years, to commence and be computed on and from the ninth day of January, which will be in the year one thousand eight hundred and eighty-two;" and although the instrument granting the second extension of five years states that it is granted "for another period of five years, to commence and be computed on and from the ninth day of January, which will be in the year one thousand eight hundred and eighty-seven." By the language of Section 17 of the Canadian Act of 1872, what was granted under it was "an extension of the patent"—of the same patent—for a further term. Therefore, the Canadian patent does not expire, and it never could have been properly said that it would expire, before January 9, 1892; and hence No. 197,314, if so limited as to expire at the same time with the Canadian patent, cannot expire before January 9, 1892.

Section 6 of the Act of March 3, 1839 (5 Stat. 354), provided that a United States patent for an invention patented in a foreign country more than six months prior to the application of the inventor for the United States patent, should be limited to the term of fourteen years from the date or publication of the foreign patent. Section 25 of the Act of July 8, 1870 (16 Stat. 201), provided that the United States patent for an invention "first patented or caused to be patented in a foreign country," should "expire at the same time with the foreign patent, or, if there be more than one, at the same time with the one having the shortest term; but in no case shall it be in force more than seventeen years." Section 4887 of the Revised Statutes provides, that "every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one, at the same time with the one having the shortest term, and in no case shall it be in force more than seventeen years."

These provisions of the Act of 1870, and of the Revised Statutes, mean that *the United States patent shall not expire so long as the foreign patent continues to exist, not extending beyond seventeen years from the date of the United States patent, but shall continue in force, though not longer than seventeen years from its date, so long as the foreign patent continues to exist.* Under Section 4887, although, in the case provided for by it, the United States patent may on its face run for seventeen years from its date, it is to be so limited by the courts, as a matter to be adjudicated on evidence *in pais, as to expire at the same time with the foreign patent,* not running in any case more than the seventeen years; but, *subject to the latter limitation, it is to be in force as long as the foreign patent is in force.*

A contrary view to this has been expressed by several Circuit Courts of the United States.

In October, 1878, in the Circuit Court for the District of Rhode Island, in *Henry* vs. *Providence Tool Co.* (3 *Ban. & Ard.*, 501), it was held that the 25th Section of the Act of July 8, 1870, meant that the United States patent should expire at the same time with the original term of a foreign patent for the same invention, without regard to any prolongation of the foreign patent which the patentee might procure from the foreign government. In that case the United States patent was granted October 10, 1871. A British patent for the same invention had been granted to the patentee on the 15th of November, 1860, for fourteen years, and expired November 15, 1874. Thirteen days after the latter date an order was made for the extension of the British patent for four years, the extension bearing date as of the day after the expiration of the original term; but the Court held that the United States patent expired on the 15th of November, 1874.

That decision was followed by the Circuit Court for the Southern District of New York, in *Reissner* vs. *Sharp* (16 *Blatchford*, 383), in June, 1879, which case arose under Section 4887 of the Revised Statutes. In that case the United States patent, granted October 20, 1874, for seventeen years, was held to have expired on the 15th of May, 1878, because a patent was granted in Canada, under the authority of the patentee, for the same invention on the 15th of May, 1873, for five years from that day, although in March, 1878, the Canada patent was extended for five years from the 15th of May, 1878, and also for five years from the 15th of May, 1883.

In *Bate Refrigerating Co.* vs. *Gillett* (13 *Fed. Rep.*, 553), in the Circuit Court for the District of New Jersey, in August, 1882, and in the same suit, in the same Court, in August 1887 (31 *Fed Rep.*, 809), in regard to the patent in question in the present suit, and on the same facts here presented, it was held, on the strength of the two Circuit Court cases above referred to, that the United States patent expired when the original term of the Canadian patent expired.

But we are of opinion that, in the present case, where the Canadian statute under which the extensions of the Canadian patent were granted was in force when the United States patent was issued, and also when that patent was applied for, and where, by the Canadian statute, the extension of the patent for Canada was a matter entirely of right, at the option of the patentee, on his payment of a required fee, and *where the fifteen years' term of the Canadian patent has been continuous and without interruption,* the United States patent does not expire before the end of the fifteen years' duration of the Canadian patent. This is true, although the United States patent runs, on its face, for seventeen years from its date, and *is not, on its face, so limited as to expire at the same time with the foreign patent; it not being necessary that the United States patent should, on its face, be limited in duration to the duration of the foreign patent.*

In *O'Reilly* vs. *Morse* (15 *How.*, 62), the patent to Morse was issued June 20, 1840, for fourteen years from that day, while § 6 of the act of March 3, 1839 (5 *Stat.*, 354), was in force, which required that every United States patent for an invention patented in a foreign country should be "limited to the term of fourteen years from the date or publication of such foreign 'letters patent.'" Morse applied for his United States patent April 7, 1838. He obtained a patent in France for his invention October 30, 1838. The objection was taken in the answer that the United States patent was void on its face because not limited to the term of the French patent. The Circuit Court held that the patent was not void, but that the exclusive right granted by it must be limited to fourteen years from October 30, 1838. The same objection was

urged in this Court, and the same ruling was made. In *Smith* vs. *Ely* (15 *How.*, 187), which was a suit on the same patent, under the same facts, the same question arose and was decided in the same way. A full and interesting discussion of the question is to be found in *Canan* vs. *The Pound Mfg. Co.* (23 Blatchford, 178), in regard to § 4,887, which contains the same word "limited" found in § 6 of the Act of 1839, which word is not found in § 25 of the Act of July 8, 1870, from which § 4887 was taken.

Under this view the time of the expiration of the foreign patent may be shown by evidence *in pais*, whether the record of the foreign patent itself, showing its duration, or other proper evidence; and it is no more objectionable to show the time of the expiration of the foreign patent by giving evidence of extensions such as those in the present case, and thus to show the time when, by virtue of such extensions, the United States patent will expire.

We find in the record in this case, among the papers which it states were submitted to the Court under the stipulation above referred to, a certificate of the Commissioner of Patents, dated July 8, 1883, appended to a certified copy of the United States patent, stating that the term thereof is limited so that it shall expire with the patent obtained by the patentee in Canada, No. 6938, dated January 9, 1877, for the same invention; that the proper entries and corrections have been made in the files and records of the Patent Office; that it had been shown that the original patent had been lost, and that the certificate is made because that patent was issued without limitation, as required by Section 4887 of the Revised Statutes. While it may be proper, in a case where the date of a foreign patent, issued prior to the granting of a United States patent to the same patentee for the same invention is made known to the Patent Office prior to the granting of the United States patent, to insert in that patent a statement of the limitation of its duration, in accordance with the duration of the foreign patent, *it does not affect the validity of the United States patent if such limitation is not contained on its face.*

It results from these views, that the decree of the Circuit Court must be reversed, and the case be remanded to that Court with a direction to take such further proceedings as shall be in accordance with law and with the stipulation between the parties above referred to, and not inconsistent with this opinion.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From December 25, 1888 to January 15, 1889 (inclusive).

Alarms and Signals:—*Automatic Fire-Alarm*, A. Watson, 395,096. *Signal-Transmitter*, J. C. Wilson, 395,101 and 395,102. *Fire Alarm Annunciator*, W. A. Barnes, 395,111. *Electric Alarm*, same, 395,112, December 25. *Electric Signaling Apparatus*, J. P. Coleman, 395,315, January 1; M. W. Dewey, 395,-958 and 395,959, January 8; W. Henion, 396,207, January 15.

Clocks:—*Controlling Device for the Regulating Members of Clocks*, W. S. Scales, 395,357, January 1.

Conductors, Insulators, Supports and Systems:—*Process of Manufacturing Insulated Conductors*, W. Siemens, 395,083. *Electric Cable Support*, C. H. Bowen, 395,207, December 25. *Electric Cable*, W. A. Conner, 395,546. *Conduit for Electric Wires or Cables*, E. H. Phipps, 395,584, January 1. *Support for Aerial Electric Conductors*, H. H. Cutler, 395,814, January 8. *Insulator Support for Electric Conductors*, L. Daft, 396,196. *Overhead Insulator*, S. H. Gilson, 396,334, January 15.

Dynamos and Motors:—*Dynamo-Electric Machinery*, F. Von Hefner-Alteneck and C. Hoffmann, 395,019. *Core for the Armatures of Dynamos*, D. J. Hauss, 394,978. *Brush for Dynamos*, E. W. Rice, Jr., 394,999. *Circuit-Controller for Dynamo-Electric Machines*, T. A. Edison, 395,123. *Dynamo-Electric Machine*, F. F. Loomis, 395,157. *Armature for Dynamo-Electric Machinery*, W. S. Belding, 395,260. *Electric Motor*, D. F. Sweet, 395,299, December 25. *Dynamo-Electric Machine*, J. F. Kelly, 395,622, January 1. *Synchronizing Device for Dynamo-Electric Machines*, C. Hoffmann, 396,086. *Thermo-Magnetic Motor*, N. Tesla, 396,121. *Unipolar Dynamo Electric Machinery*, R. Eickemeyer, 396,149. *Armature for Dynamo-Electric Machines*, L. Daft, 396,195. *Electro-Dynamic Machine*, C. Coerper, 396,269. *Commutator-Brush Carrier for Electric Motors*, C. J. Van Depoele, 396,314. *Dynamo-Electric Machinery*, I. T. Dyer, 396,355, January 15.

Galvanic Batteries:—*Battery-Cell for Electric Belts*, S. Colling, 394,958, December 25. *Dry Voltaic Battery*, I. Kitsee, 395,706. *Voltaic Battery*, T. Coad, 395,769. *Mode of Preparing Solution Compounds for Galvanic Batteries*, W. P. Kookogey, 395,835. *Method of Preparing Solution Compounds for Galvanic Batteries*, same, 395,837, January 8. *Galvanic Battery*, P. R. De F. D'Humy, 396,329; B. Scheithauer, 396,342, January 15.

Ignition:—*Electric Appliance for Discharging Guns*, B. A. Fiske, 396,199, January 15.

Lamps and Appurtenances:—*Sign for Electric Lights*, E. A. Dubey, 395,317, January 1. *Holder for Electric Arc Lamps*, J. Pawlowski, 395,755. *Regulator for Incandescent Electric Lighting Systems*, M. J. Wightman, 395,936. *Method of Manufacturing Electric Lamps*, T. A. Edison, 395,962. *Incandescent Lamp Filament*, same, 395,963. *Coupling for Gas and Electric Light Fixtures*, R. Herman, 396,039, January 8. *Head-Light*, J. F. Shawhan, 396,241, January 15.

Measurement:—*Electric Meter*, E. Thomson, 395,018, December 25. *Electrical Measuring Apparatus*, H. V. Hayes and A. C. White, 395,974, January 8.

Medical and Surgical:—*Medical Battery*, H. E. Waite, 395,932, January 8. *Electrical Body-Wear*, J. V. Long, 396,212, January 15.

Metal Working:—*Mode of Covering Surfaces of Metal with Lead*, O. Elberling, 395,269, December 25. *Manufacture of Electrotype of Stereotype Plates*, J. Dale, 395,488, January 1. *Cathode for an Electro-Depositing Apparatus*, E. Emerson, 395,773. *Process of Electric Welding*, C. L. Coffin, 395,878. *Forming, Brazing and Welding of Metals by Electricity*, E. Thomson, 396,009. *Method of Electric Forging*, same, 396,010. *Method of Electric Welding*, same, 396,011. *Apparatus for Electric Welding and Working Metals*, same, 396,012. *Electric Pipe-Joining and Pipe-Work*, same, 396,013. *Electric Metal Working*, same, 396,014. *Method of Electric Riveting*, same, 396,015, January 8. *Process of Electric Welding*, C. L. Coffin, 396,270. *Magnetic Separator*, T. A. Edison, 396,356, January 15.

Miscellaneous:—*Overloading and Slack Cable-Stop for Electrical Hoisting-Machines*, W. Baxter, Jr., 394,952. *Rheostat*, S. Bergmann, 395,116. *Toll Apparatus for Producing Electric Light*, D. H. Davies and J. M. Tourtel, 395,215, December 25. *Lightning-Rod*, L. L. Mast, 395,399. *Safety-Device for Use in Electric Circuits*, A. C. Cockburn, 395,421. *Regulator*, A. Gartner, 395,492. *Electrically-Operated Cutting Device*, R. Thayer, 395,524. *Automatic Safety Cut-Out for Electric Circuits*, G. T. Woods, 395,533. *Electro-Magnetic Rock-Drill*, H. N. Marvin, 395,575. *Electrical Switch*, P. H. Brangs, 395,609. *Wire Splicer and Cutter*, H. V. Wulbecke, 395,642, January 1. *Art of Compiling Statistics*, H. Hollerith, 395,781. *Apparatus for Compiling Statistics*, same, 395,783. *Apparatus for Indicating and Recording Changes at a Distant Point*, G. E. Winslow, 395,862. *Electrical Heating*, J. V. Capek, 395,950. *Electrical Store-Service Apparatus*, R. N. Dyer, 395,961, January 8. *Attachment for Pianos*, F. W. Hale, 396,156. *Electric Coupling for Hose-Pipes*, D. J. Simpson, 396,176, January 15.

Railways and Appliances:—*Device for Automatically Stopping Trains*, I. L. Meloon and P. S. Whiting, 395,163, December 25. *Conduit Electric Railway*, B. Jennings, 395,442. *Electric Railway Signal*, D. G. Smith, 395,667, January 1. *Electric Train-Brake Apparatus*, A. I. Ambler, 395,682. *Trolley for Electric Railways*, W. F. Jenkins, 395,703. *Conduit for Electric Railways*, S. Trott, 395,761, January 8. *Suspended Switch for Electric Railways*, C. H. Wells, 396,124. *Traveler for Electric Railways*, C. J. Van Depoele, 396,310. *Hooked Suspender for Electric Railway Conductors*, same, 396,311. *Suspension Device for Electric Railway Conductors*, same, 396,312. *Adjustable Crossing and Switch for Overhead Conductors*, same, 396,313. *Railway Signal*, W. C. Paul and O. D. Kleinsteuber, 396,365, January 15.

Storage Batteries:—*Flexible Sealed Cell for Secondary Batteries*, M. Baily and J. Warner, 395,028, December 25. *Insulating Support for Secondary Battery Electrodes*, H. F. De B. Cameron, 395,311. *Secondary Battery Charging*, C. F. Brush, 395,377, 395,378 and 395,379, January 1. *Apparatus for Charging and Discharging Secondary Batteries*, W. P. Kookogey, 395,836, January 8. *Secondary Battery*, O. Lugo, 396,213 and 396,214; I. L. Roberts, 396,367, 396,368 and 396,369, January 15.

Telegraphs:—*Electric Telegraphy*, M. W. Dewey, 394,960. *Telegraphic Printing Code*, same, 394,961, December 25. *Automatic Telegraphy*, P. B. Delany, 395,427. *Multiplex Telegraphy*, F. J. Patten, 395,508, 395,509 and 395,510. *Vibratory Multiplex Telegraphy*, S. D. Field, 395,556. *Electro-Harmonic Telegraphy*, M. W Dewey, 395,613. *Printing Telegraph*, same, 395,614, January 1.

Telephones, Systems and Apparatus:—*Telephone Apparatus*, U. H. Balsley, 394,951. *Electric Switch-Board*, I. H. Farnham, 394,964. *Hotel Telephone System*, 395,187, December 25. *Speaking Telephone*, F. Blake, 395,476, January 1.

EXPIRING PATENTS.

Patents relating to Electricity which become Public Property in February 1889.

Reported for the ELECTRICAL ENGINEER, *by* F. B. Brock, *Patent Attorney*, 639 *F street, Washington, D. C.*

Fire Telegraph, W. H. Mumler, 123,355; *Magneto-Electric Machine*, A. N. Allen, 123,438; *Gas-Lighting, Electric*, A. N. Allen, 123,439; *Telegraphs*, W. C. Barney, 123,441; *Electric Railway Signal*, H. S. L. Bryan, 123,449; *Relays and Sounders*, G. Little, 123,490; *Automatic Telegraph*, G. Little, 123,491; *Railway Signal*, Verny & Veillet, 123,527, February 6, 1872. *Lightning Rod*, Wells & House, 123,600; *Automatic Telegraph*, G. Little, 123,711, February 13, 1872. *Annunciator*, C. E. Churnock, 123,808; *Insulator*, D. R. P. Emminger, 123,878; *Arc-Light*, A. A. Meynial, 123,923; *Electrolysis*, J. H. Rae, 123,932; *Lightning Rods*, D. F. Welsh, 123,958; *Fire Telegraphs*, Wright, Holley & Miles, 123,970, February 20, 1872. *Automatic Fire Telegraph*, T. A. Edison, 123,984; *Electric Clock*, E. Wilson, 124,104; *Gas Lighting*, S. Gardiner, Jr., 124,126, February 27, 1872.

[Drawings and specifications of any patent will be furnished by Mr. Brock at cost, 15 cents each.]

THE

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Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

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VOL. VIII. NEW YORK, MARCH, 1889. No. 87.

THE DECISION OF THE COMMISSIONER OF PATENTS IN THE TELEPHONE INTERFERENCES.

WE have delayed this issue of the ELECTRICAL ENGINEER to print in full the decision of the Commissioner of Patents in the long pending interferences between Bell, Gray, McDonough and others, because of its scope, significance and general interest.

The decision derives much of its interest and significance from the fact that it covers substantially all the charges of fraud made in the pending Government suit to annul the Bell patents. This puts the Government suit in a rather curious position. The United States, through its Attorney-General—who does not know anything about such matters—alleges by a bill, which nobody swears to, that there ought to be inquiry as to whether there was any malpractice or fraud in the Patent Office. Now the United States, by the officer who does particularly know of such matters, in the exercise of its undoubted jurisdiction, summoned Mr. Bell into the Patent Office before that bill was filed, and heard argument after it was filed, and made the very inquiry which the Attorney-General says ought to be made, and decides that all those charges are groundless. This case before the Commissioner of Patents, which consists of a motion of Gray for leave to amend, and a motion of Gray and a motion of McDonough to reopen, has been argued at very great length in the Office. In March, 1887, the McDonough motion was heard before Commissioner Montgomery, General Duncan and Mr. Jefferson Chandler—the latter being one of the Government counsel in the suit against Bell,—appearing for McDonough. In May, 1887, Gray's motion to amend was argued before the Primary Examiner, who decided against him, and was again argued before the Commissioner in person the first week in December, 1887, by Mr. Phillipp and Mr. Casey Young, for Gray; Mr. Conkling and Mr. Storrow against him. The motion of Gray and the motion of McDonough to reopen were argued for eight days before the Commissioner, beginning February 1, 1888, by Col. Ingersoll, Mr. Frank Hurd and Mr. Humphreys, counsel for the Meucci Co., as counsel for McDonough. It was also argued by Mr. Casey Young orally, and by Mr. Phillipp subsequently in a long printed brief, for Gray. By consent of Mr. Bell's counsel they pitchforked in everything they could find in any of the other cases, including the evidence at the hearing before the Secretary of the Interior in the fall of 1885, and all this was argued on the first occasion by one of the Government counsel, though on a rather limited part of the case, and later by the Pan-Electric counsel and by Gray's and McDonough's special counsel. The case might well have been dismissed on the ground of laches, but at the hearing the Bell counsel as well as the Commissioner expressed their disinclination to that course. In the present decision the Commissioner has gone at great length into the whole intrinsic merits of the controversy, and has declared that he reaffirms the earlier decisions because they were right.

It is interesting to refer to the decision of Secretary Lamar, in which he said that he neither formed nor expressed any opinion as to the merits, but merely that there ought to have been an inquiry. There has now been an inquiry of the most elaborate nature, and here is the result.

The present position of the Commissioner is worth noticing also. He was one of the Democratic majority of the Pan-Electric investigating committee; the result of which may fairly be regarded as more political than judicial; he was personally selected by Mr. Secretary Lamar to be Commissioner of Patents, because Mr. Lamar knew him personally and thought very highly of him; and he was appointed by President Cleveland. He has come to this conclusion because no other is possible, and the perusal of the very full statement which he makes of the case will, we believe, convince all candid readers of the justice of the decision.

THE ELECTRIC LIGHT CONVENTION AT CHICAGO.

WE are sorry to have to say it, but the discussions of the February Convention of the National Electric Light Association appear to have been unusually windy, dreary, inconclusive and unprofitable.

The opening address of President Duncan, however, presented a striking array of figures showing the growth of business in electric lighting and railway service during the past year, arranged in a clear and effective manner.

The Association did well, we think, in committing itself to the further continuance of a headquarters in New York under the charge of the Secretary and Treasurer appointed October 1st, Mr. Allan V. Garratt. The permanency of the office as now established depends chiefly upon the pecuniary resources of the Association. With an adequate representation of the thousand or more central station operating companies of the country in the membership, that question would settle itself promptly. While we can-

not regard the proceedings of the recent convention as likely to prove attractive to electrical companies or firms eligible to membership, we believe that the experiences at Chicago, of all who took interest enough in what was said and done on the floor of the convention and elsewhere, point out unmistakably not only the existence of breakers ahead but how to steer away from them. It is a gratifying circumstance that there was substantial unanimity in all action taken by the convention as to the administration of the affairs of the Association for the coming year, including the appointment of a committee to revise the constitution, which proves imperfect in several respects notwithstanding its revision six months ago.

The unanimous election of Mr. Edwin R. Weeks to the presidency ensures a wise oversight of the Association's interests and a judicious consideration of its future policy.

The Association owes its inception, we believe, to the initiative of Mr. Geo. S. Bowen, of Elgin, Ill., who saw clearly the possible usefulness of an organization of practical men, operating electric plants for the purpose of making money for their owners, with meetings for the interchange and comparison of experiences and the suggestion or adoption of improved methods of practice and administration. During its five years existence much has been done to justify Mr. Bowen's endeavors. The relative sterility of the recent convention was unquestionably due to the absorption of general attention in matters quite foreign to the true purposes of the Association, matters necessarily dealt with in committees, conferences and caucuses outside the convention, but bringing every member on the ground under their influence. We do not believe that the conditions which produced such a state of affairs will be permitted to arise again.

The Convention warily declined to commit itself to any deliverance on such questions as Underground Conductors, Petroleum Fuel, Municipal Lighting, etc., but it is a pleasure to record that it braced up to positive action on one subject. Though hungry and anxiously awaiting recess for luncheon, the Association acted promptly and decisively on the preamble and resolution offered by our genial friend, Dr. Moses, touching the pernicious activity of "a certain individual" in "exaggerating the dangers of electric currents" and striving "to influence legislation" to secure "the introduction of electricity" for the infliction of capital punishment. A handsome majority resolutely and manfully voted that the "National Electric Light Association earnestly protests against those efforts and unanimously resolves that the members of this body decline to allow any electric current under their control to be used for ignoble purposes." We may now expect, of course, that the ill-starred agitator will promptly withdraw his objectionable pamphlet from circulation. Even the anonymous notoriety conferred upon him by the Association must prove a fatal blow to his nefarious purposes. It is perhaps regrettable that out of well meant kindness Dr. Moses carefully concealed the identity of the obnoxious person under his designation as "a certain individual."

Can "the individual who happens to be meant" be the eminent electrical engineer whose plan of shutting off a circuit automatically by any accidental grounding, and thus leaving hundreds of people in darkness and danger, was so felicitously characterized by Mr. T. Carpenter Smith on the floor of the convention?

The Electrical Exhibition in connection with the convention was an undeniable success, not only in its extent and variety, but notably in its attractiveness to the people of Chicago. The vast number of visitors was truly surprising.

The new Mayor of New York, Hon. Hugh Grant, takes decided ground in electrical subway affairs. He evidently means to do what he can to get the wires underground, on all routes provided with conduits. Apparently he has no doubt of the entire feasibility of the present subway plans; at all events, he wants to have them faithfully tried, and seems disposed to push forward the construction of conduits on cross-town routes. It would seem wiser to await the result of a thorough trial of existing conduits before laying more. The amusing Mr. Gibbens, always against the Mayor, now takes up the cudgels for the electrical companies, but has already had a knock down or two from Mr. Grant. The new Mayor takes subways too seriously for joking, and we regret the prospect of missing the fun with which Mr. Hewitt and Mr. Gibbens enlivened the tiresome proceedings of the Board of Electrical Control during the former's term of office.

The Metropolitan Electric Supply Company of London, has in our opinion, shown, a wise discretion in awarding the contract for its second central station plant to a home firm of good standing and reputation. With an English and an American concern working at a similar undertaking, under like conditions, and almost side by side, each will be stimulated to show its best work. The contest between these two plants and the great installation at Deptford, will certainly become interesting, and is not unlikely to be very instructive.

Our esteemed transatlantic contemporary, the London *Electrical Review*, is respectfully informed that the only theory, which seems to account for the origin of the mysterious despatch sent out from Buffalo, once upon a time, announcing the total failure of the Westinghouse plant in that city, is based upon the Wellerian hypothesis of coincidences. President Johnson of the Edison Company, is said to have stayed in Buffalo "that wery" same night. But it may be remarked, in passing, that the statement was not true.

In a pamphlet distributed at the Chicago convention, the assertion is made that Walter K. Freeman, now of Eau Claire, Wis., "made and sent to Thomas A. Edison, the first incandescent lamp made with a hight resistance carbon, that he, Edison, had ever seen," and it is therein further stated, that Edison repeatedly admitted to Freeman, in the presence of witnesses, that he received from Freeman an incandescent lamp, upon which he, Edison, based his subsequent experiments. Whether, if true, this is important, would seem to depend largely upon the precise construction of the said lamp, respecting which the author, perhaps wisely, preserves a discreet silence.

AMONG the number of special assemblages to be got together during the French Exhibition, a Congress of Commercial Travelers is announced to be held at Paris, July 9th to 12th. Here is an excellent opportunity for the American drummer. In an "experience" meeting we have little doubt he would be able to hold his own with The Illustrious Gaudissart himself. Although the Congress will be held at a rather warm season, we take the liberty of suggesting to the American delegation some modification of the costume in which the deputation of commercial travelers paid their respects to General Harrison last summer. We fear that the apparition of a considerable body of men arrayed in "long linen dusters, shiny black hats and a new style of umbrella" would prove too much for French gravity.

ONE consequence of the decision of the Supreme Court, in the Bate case we do not remember to have seen touched upon in the numerous discussions which have taken place in relation to the subject. It was held by Judge Wallace in the Circuit Court of New York, in 1886, reaffirming three or four prior Circuit Court decisions in cases in which the facts were similar, that the domestic patent for an invention previously patented abroad for a term of 14 years, does not expire until 14 years from the date of the foreign patent, notwithstanding the grant might have terminated by the failure of the patentee to pay the taxes due at the expiration of three years. This decision would apply to a patent in Great Britain, France, Belgium, and many other countries, but the Supreme Court now holds, apparently, that the domestic patent can only remain in force so long as the foreign patent remains in force. The consequence will be, that many patentees, who under the Circuit Court decisions have always regarded their patents as valid, will find that they have expired by reason of the failure of the owners of the foreign patents to pay the periodical taxes; a discovery, which will no doubt constitute an unpleasant surprise to more than one owner of electrical patents. The doctrine upon which the decisions of the lower courts have uniformly been based, is that the term of the American patent was determined by the condition of the foreign patent at the date of the domestic grant, and that nothing thereafter done to the foreign patent, either by way of extension or curtailment, could in anywise affect the rights of the inventor in this country. The Supreme Court now rejects this doctrine with emphasis, and it appears to us that the consequences in some directions are likely to be serious.

THE decision rendered by the Commissioner of Patents of the Dominion of Canada, revoking Edison's patent of November 17, 1879, for incandescent electric lamps as noted in our news columns, is one of great importance to electric lighting interests in the United States. Under the decision of the United States Supreme Court recently given in the Bate Refrigerator case, Edison's fundamental lamp patent in the United States, No. 223,898, would seem to be dead beyond hope of resurrection. The Canadian decision is final in respect to that jurisdiction, while our Supreme Court, as we have elsewhere pointed out, in commenting upon the Bate case distinctly announces the doctrine that the domestic patent can remain in force only so long as the prior foreign patent remains in force, which is apparently conclusive.

OBSERVATIONS.

ONE of the signs of the times is the facility which the general public, and especially the rising generation exhibits, in adopting and using electrical phrases.

When a person is much astonished or overwhelmed he is *electrified*; we talk of *lightning speed*, or of the *lightning* express. A young teamster who lives in our town, has such a mania for anything electrical, that he not only attends all the lectures and reads with avidity all the books relating to electricity to which he can obtain access, but he also experiments during his spare time, and in his working hours actually speaks of harnessing his horses in *series*, or *multiple arc* as the case may be; and is never at the close of the day tired; he is only *polarized*.

. . .

WAS there ever a more overworked word than this same "polarized;" or a more overworked idea than "polarization?"

An electro-magnet is so mounted upon a permanent magnet that the two poles become of like magnetism, while its armature mounted so as to vibrate between them acquires a magnetic polarity of opposite character: and lo! we have a polarized relay."

A voltaic battery placed on short circuit acquires a deposit of hydrogen over the surface of its negative plate, so that its internal resistance is raised, and so that the ratio between the positive and negative plates in the electro-chemical series is changed; and our battery is "polarized." So again we speak of a beam of "polarized light," etc.

No wonder that the brain of the student often becomes polarized in finding out *all* about electricity.

. . .

THE Boston *Advertiser*, in common with many other daily papers, and doubtless stimulated by the glittering success of the New York *Sun* in its scenes from the real life of celebrated inventors, has established an electrical column. The following head-line recently adorned that column:—

"Electrical Treatment of Alcohol in Beets."—A first glance indicated that a really philanthropic use had at last been found for the invisible force which is always in its infancy; but a calmer and more protracted examination revealed that *Beets* was after all, the proper spelling, and that the item above, referred to a method employed in France for purifying the products of the distillation of beets by means of electricity.

. . .

INCIDENTS in electrical experience repeat themselves as certainly as history does—or as the many coincidences or double occurrences, with which every observer is familiar, in the every-day life of all of us.

Looking over some old files of the *Telegrapher*, a few days ago, the observer came across the interesting account of a Western Union superintendent, who wasn't much on electricity, but take him on authority, and he was there. It stated that this worthy gentleman happened into one of the offices in his district once upon a time, when it chanced that there was but one wire working to Kiachta, a place to which he wished to send a message; "Can't you raise Kiachta" said he? "No," said the operator, "this is the only wire we've got, and I can't raise him on here;" "Switch it round on some of the other instruments," was the reply, "you'll raise him somewhere."

Within an hour after reading of this incident, the observer's attention was called to a similar instances of recent occurrence, in which a telephone official figured as principal. Mr. John Smith (let us say) who is popularly supposed to be perfectly at home with his art, sends a call to Central, and wishes to talk to a storekeeper up-town; in three minutes the operator reports "No. 293 don't answer"; "Don't answer" vociferates J. S., "Tell him he must!"

ARTICLES.

ON THE PLACE OF ACCUMULATORS IN ELECTRIC LIGHTING.

BY GEORGE B. PRESCOTT, JR.

It has been remarked that the electric light will not fulfill all the requirements of an universal illuminant until some method of accumulating and storing electricity for future consumption, similar in effect to that by which illuminating gas is now reservoired in gasometers, has been discovered. Those who are familiar with the subject are aware, however, that the only known method of accumulating electricity *per se*, is through the medium of thoroughly insulated surfaces, as exemplified by the Leyden jar and other forms of condensers; and they know, moreover, that electricity so stored is not available for use in any of the commercial industries in which continuous currents of controllable magnitude and duration are required. The dynamic electricity of batteries and dynamos—if the distinction may be allowed—cannot, therefore, be directly stored for subsequent use in commercial lighting, but it is possible to transform currents so produced into other available forms of potential energy. When so transformed this energy may be controlled at will, and reconverted into electricity at such times and for use in such quantities as may be required.

The storage battery, or modern accumulator, is an instrument capable of effecting this kind of transformation and of bottling up energy so to speak, although, like the primary battery and the dynamo machine, it in no sense stores electricity. In short, the current with which it is charged merely causes certain chemical changes to take place in the constituent elements of the accumulator, and when the charging is discontinued, if the elements are placed in electrical contact, they tend to resume their previous condition, restoring, in the process of reuniting, the electricity which effected the separation.

Whenever one kind of energy is transformed into another kind, more or less loss can be shown to occur, and the action of the accumulator is not an exception to this rule. The proportion of loss generally varies with the conditions under which the transformation is effected, and in the case of the accumulator depends mainly upon the rate of charge and discharge. If these double transformations are conducted slowly the loss may be nearly inappreciable, but at the higher rates which are frequently demanded in practice the efficiency is proportionately reduced. The fact of the existence of this loss clearly indicates that the direct production and consumption of electricity must always be less expensive, both in original outlay and cost of production, than its subsequent use through the medium of accumulators; unless, indeed, there are other modifying conditions which overbalance the additional cost of accumulators and offset their maintenance. That such conditions do exist in many branches of the electric lighting industry can be readily demonstrated, and it may likewise be shown that the use of accumulators as auxiliaries to many existing lighting plants would insure a marked reduction in their running expenses. While it would be absurd to assert in a general way that the accumulator is a superior substitute for all direct lighting systems, and justly expose the views of such a claimant to merited condemnation, it would display equal ignorance to deny that the modern accumulator is a valuable adjunct to the art of electric lighting.

To whatever service accumulators may be applied, however secondary their function in the installation of which they form a part, a nice attention to every detail of their equipment is essential to successful operation. Not the least important part of every accumulator installation is that which pertains to the proper regulation of the quantity and pressure of the current during charge and discharge. This portion, simple as it is, embraces novel and distinct features peculiar to the system, the details of which have been gradually developed as practical experience has shown to be necessary; just as the higher perfection of any art is always reached by a gradual process. Physical apparatus should, of course, be selected with reference to the particular service which it is destined to perform, and it would be folly to attempt to accomplish by means of accumulators results which could be produced to better advantage by other means. It is necessary, therefore, that the applications of accumulators should be undertaken in this spirit by those who are competent to discriminate, as, otherwise, the results accomplished may prove to be as detrimental as they might have been beneficial. If accumulators are intelligently utilized to meet those conditions to which they are by their nature adapted, if they are properly installed with reference to regulation, and faithfully maintained in accordance with the instructions of the manufacturers, they will be found as serviceable and reliable as any other class of electrical apparatus. In the matter of maintenance, accumulators probably require less supervision and attention than is commonly bestowed upon steam boilers, engines and dynamos, or even upon primary batteries, and yet frequent inspection, and proper attention when they do require it, is unquestionably demanded. Neglect of this requirement, like a failure to keep water in a boiler or oil on a crank pin, would very likely result in a serious injury to the plant.

The place of accumulators in electric lighting is a broad one, and it will be sufficient to mention in a general way a few of the conditions ordinarily existing in both central station and isolated incandescent plants, in order to indicate it. It is an undisputed fact that the economy of a given steam power plant is a maximum when the load is a maximum, and that the pounds of coal per horse-power increase as the power decreases. It follows from this that a direct lighting plant can only be operated at its maximum economy when running at its maximum capacity. From what has already been said regarding the infallible certainty of loss resulting from any form of conversion of energy, it is evident that if the load were equal to the capacity of a plant for 24 hours each day no system of conversion could compete in point of economy with one which effected the direct production and use of the current. There is an exception even to this general statement, however, when one or more groups of lamps are located at such a great distance from the source of power, that the interest on the cost of conductors together with the cost of the energy wasted in them, becomes of serious importance; not to mention the increased difficulties of regulation. In cases of this character, the value of the accumulator as an auxiliary to a direct incandescent system becomes obvious. The cells may be located directly at the centres of consumption and charged by a moderate current at high pressure over a small conductor. They may be charged during the hours of light load and discharged as required; the whole charging current, in addition to the current of the batteries, being available on the lamp circuits, during the period of maximum load, if it should be so desired. Often the interest on the cost of such an accumulator installation plus the cost of the energy lost in conversion of current, is much less than the loss by the direct system as previously specified. Another and vastly important consideration in favor of the accumulators is that during the 10 or 12 hours of each day when the consumption of current is so small that a station can only be operated at a loss, the power could be shut off entirely and the accumulators resorted to for the current required during that period.

As a matter of fact, the ideal condition of a continuous maximum load, as assumed above, nowhere exists in practice. The actual load curves for stations of similar capacity throughout the country differ not only in respect to the duration of the maximum period, but likewise in the hours

during which the light and heavy loads occur, according to the character of the lighting. It is nevertheless true that they all show a remarkable similarity in the variation of current consumption, and all the 24 hour stations, particularly the smaller ones, require but a very small portion of the capacity of the plant for the greater part of the day. For this reason, many of the smaller stations cannot be profitably operated for more than 12 hours a day, and customers are therefore unable to obtain the light for the remainder of the 24 hours, the system being thereby deprived of much of its value to many consumers.

Here again the utility of the accumulator for tiding over these costly periods of light loads become apparent. It is evident that any ordinary station running for 12 hours a day, more or less, is not likely to have an output approaching its capacity for more than two hours at the longest, while for the greater part of the time it will be much below it. Why should not such a station be operated during that period of 12 hours at somewhere near its full capacity, and, therefore, under the most economical conditions for the power produced, and utilize the excess of current to charge a sufficient number of accumulators to maintain the lighter load during the remainder of the day?

This is the legitimate work of accumulators, and when they are properly installed and maintained to meet such conditions, the class of small stations referred to will be enabled to supply satisfactory light for 24 hours a day at moderate cost, while the larger stations may greatly reduce their running expenses and at the same time maintain the efficiency of their service.

For a certain class of central station work the accumulator has a field of its own, viz.: the lighting of a district in which the consumers are scattered to such an extent as to make the cost of distribution and regulation prohibitory to any multiple arc system. In cases of this sort the accumulators are, of course, located at small centres of consumption, in such numbers as to meet the requirements. Unoccupied cellars and lofts may be obtained for the accomodation of the cells at a nominal rent, and a single charging circuit may be arranged to take in all of these sub-stations.

Still another application of accumulators has met with considerable favor in some of the smaller towns already operating arc systems. In stations of this character it is not unusual to find that the power plant is only equal in capacity to the arc lamps in use, and while the owners would be glad to be able to supply a limited number of incandescent lights, they object to incurring the outlay for additional boiler and engine capacity. To meet conditions of this kind a sufficient number of cells are installed where required on the series system, and charged by the regular arc dynamo during the day. When the lighting hour arrives the dynamo is changed to the arc circuit and the accumulators then left to take care of the incandescents.

Again, there is no difficulty about installing accumulators on ordinary arc circuits, and this method offers in fact the only satisfactory solution of the problem of operating incandescent lamps on arc circuits. The failure of one or more of the incandescents does not subject the remainder to any excessive strain, and no cut-outs or other automatic devices are required. Moreover, the fluctuations of the arc current are largely compensated by the battery.

Whatever advantages may be gained by the use of accumulators as auxiliaries to central station work, they will prove even more useful and economical when applied to any kind of isolated plant. Indeed, for the latter work, they are usually indispensable. Such plants are generally installed where the necessary steam power is already available, although occasionally the whole generating plant is provided especially for the purpose. In either case the major portion of the lights are only required within a period of ten hours or less, although there are very few instances in which it would not be desirable to the owners to have a limited number of lights for the whole 24 hours, if it were not for the proportionately greater expense entailed by the operation of the plant for that length of time. Now it can be shown that in most plants of this character the same general load curves obtain that have been found to prevail, as already indicated, in central station supply, and it is evident, therefore, that for such plants as are ordinarily operated for from eight to ten hours a day, there would be surplus capacity for a sufficient length of time each day to charge enough accumulators to carry the light load for the remainder of the 24 hours. Under such circumstances the total capacity of the plant could also be increased in case of necessity, by allowing the accumulators to discharge into the lamp circuit at the same time that the dynamos were delivering their maximum output. As it frequently happens that a large isolated plant will not require anywhere near its full quota of lamps at any one time, and yet must have the total current capacity available in the event that it should be wanted, this flexibility of the accumulator system permits of the installation of a much smaller dynamo plant than would otherwise be required, the saving thus made in first cost going a great way towards paying for the accumulators themselves.

As in the case of the central station auxiliary accumulators, already cited, their use in isolated plants enables the power plant to be operated at its maximum efficiency during its running time, and, while supplying light for 24 hours entails only an ordinary day's labor on the regular staff.

As a means of utilizing variable or intermittent power, such as that of waterfalls or windmills, in the production of electric light, the accumulator can hardly be said to have a rival.

The operation of a plant composed wholly or partly of accumulators demands a certain amount of hand regulation, as is practically the case to-day in every direct system. Convenient and reliable apparatus for this purpose is provided, and nothing is lacking in this respect to insure a uniform pressure at the lamps.

The several accumulator systems are, however, more susceptible to various methods of automatic regulation than perhaps any system involving the continuous running of dynamos, and while the supply of automatic devices is not fully complete at present, the increasing use of accumulators will undoubtedly create the demand which will bring them forth in due time.

A NEW SYSTEM OF MULTIPLEX TELEGRAPHY.[1]

BY LIEUTENANT F. JARVIS PATTEN, U. S. A.

THE paper this evening has a single object, its purpose being to describe the salient features of a system of multiplex transmission by telegraph, and as the system is still in the experimental stage, I shall have more to say concerning devices thus far used wherein practical results have come near to the indications of theory, than as to the actual possibilities of the system in use. The general subject is so familiar to all present that a review of the different methods of multiplex transmission is scarcely necessary. Suffice it to say that the system under consideration falls under the general class of synchronous multiplex telegraphs which depend for their operation upon the absolute or approximately uniform rate of movement of similar apparatus placed at the different stations of a line.

In the interest of those present who may not be familiar with the fundamental principle underlying all systems of multiplex transmission, I will give a brief description which will be understood by reference to figure 11. A line wire is shown connecting two distant points, at each end of which is placed a machine which carries a revolving brush or trailer, which is caused by some form of mechanism to

1. Read before the American Institute of Electrical Engineers, February 12, 1889.

sweep over a circular table of contacts ; this is sub-divided, as shown, into a convenient number of segments insulated from each other. Each of these segments is connected to a branch circuit, which includes all the necessary instruments for a single operator sending or receiving. If we consider the trailer motionless and resting on, say, the segment No. 1, then the two operators at the end of the line would each evidently find the main line connected to his sending and receiving apparatus for the time being, and if the trailer remained in the position shown, they could hold uninterrupted communication with each other. If, now, the trailers were moved to the segments No. 2, in each distributor, then operators No. 2 at each end would have the line. It will now be understood that if by any means the trailers could be revolved uniformly around the circle the line would be given in turn to each of a number of operators in succession. Evidently it would be feasible to move the trailers slowly from one segment to the next and so give the line in turn to any number of operators connected, in the manner described, to the main line.

Early attempts at multiplex transmission did not go farther than this. The line was given slowly first to one and then to another operator, the time that each in turn could hold communication being indicated by a common metronome. Later attempts went farther than this, the idea being to make the trailers revolve at a high rate of speed, moving in fact, so fast, that each operator in turn is connected to the line so rapidly that he is practically unaware that the line has ever been taken from his circuit. It is easy to see that this would not require a very high rate of speed. If it be assumed that the operator can make the shortest signal with his key in one-fifth of a second, it only becomes necessary to move the trailers at a speed of more than five revolutions in a second, when it would evidently be impossible for any of the operators to close a key without having the line during this interval connected to his branch circuit. In order that the signal sent by any operator shall reach the corresponding operator at the other end of the line, it becomes necessary, of course, that the trailer at the two stations should be on the same identical segments at the same instant of time. The solution of this problem will then consist in causing the trailers, however far apart, to move with absolute uniformity and precision. If this can be done at a sufficiently high rate of speed then a single wire may be given in rapid succession to a number of operators at each end, and all can simultaneously communicate over the single wire without interruption from or interference with each other.

Such a system has for its object the utilization of all the currents which in a given unit of time can be distinctly transmitted over a single wire. If it is assumed that in average Morse transmission five pulsations of current or makes and breaks of the circuit occur in every second, then if n represent the number of separate currents that can be made to succeed each other during this interval of time, $\frac{n}{5}$ will represent theoretically the number of receivers or operators that can work the same wire at the same time.

Any system based upon the foregoing theoretical consideration, which consists practically in giving the line for a brief interval of time to a number of operators in rapid succession, rests fundamentally upon the fact that the identical revolutions in the same period of time of certain parts of the apparatus at different stations can be maintained continuously, in other words, a perfect synchronizing device of some sort must be the fundamental starting point without which any such system will remain what a noted English scientist has aptly described as a "mere figment of the intellect."

In the literature of the telegraph, already large, synchronizing devices are common, and in the books their operativeness is generally taken for granted. All such devices, with a single exception that occurs to me, are founded upon the isochronous motion of some mechanism which, under the operation of natural forces, has a fixed rate of movement, and preserving this motion unvaried so long as these forces are acting freely. The pendulum and the tuning fork perform their oscillations of great or small amplitude in the same period of time ; their rate of movement is, therefore, described as being *isochronous.* Two such exactly similar devices while in motion, therefore, should be in *synchronism* with each other ; but all these devices once set in motion immediately tend to a state of rest, and it becomes necessary to apply constantly some extraneous force to keep them in continued operation ; they must continually receive an intermittent impulse to prevent them from coming to a state of rest. The natural rate of movement of the apparatus, which is alone the result of the uninterrupted action of the forces in the system, is thus made subject to a slight but constant disturbing effort.

In view of these considerations which have been expressed in the most general terms, it has been my endeavor to perfect a synchronizing device that should be independent of the uniform rate of motion of any part, the general statement of the problem being to devise apparatus which shall move in unison with each other at a variable instead of at a constant rate of speed. Recent electrical inventions point clearly to an ultimate solution of this problem, if it has not already been achieved. A pertinent illustration of this fact is found in the common speaking telephone, so common that variable synchronism is already in daily use among those who regard matters electrical as full of mystery. In this apparatus the diaphragm of the receiving instrument moves in perfect synchronism with that of the transmitter, and it seems by no means an exaggerated comparison to regard the receiver as an alternating current motor moving in perfect unison with the changes of potential in the generator and the line circuit. My experiments in this field were first directed to the application of this peculiar relation of the alternating current generator and motor to a synchronizing device only to reach the conclusion, however, that it could not be made operative on a circuit of any considerable length.

Further experiments led to a simpler solution of the problem involving few uncertain elements.

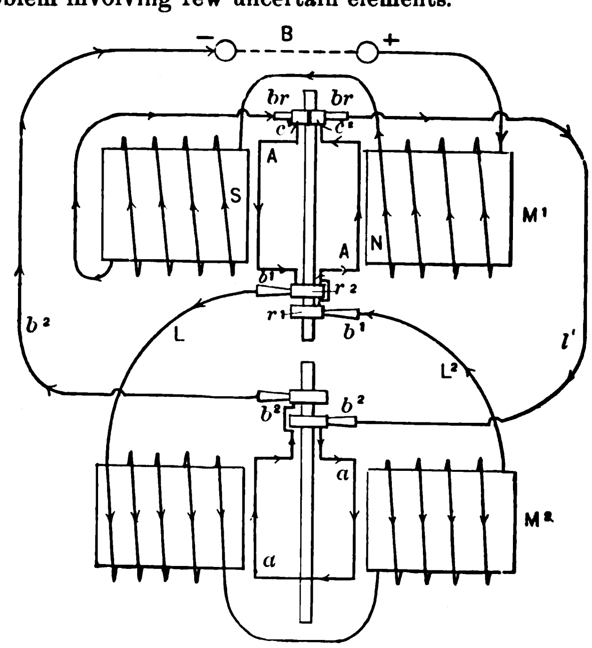


FIG. 1.

I had constructed two ordinary direct current motors of the simplest form, an ordinary two-pole field and single coil armature conveniently arranged for use as either direct or alternating current machines. The armature circuits were connected at one end to an ordinary two-part commutator and at the other to two

insulated ring contacts. They are shown by a simple diagram in figure 1, where both are connected in a single circuit. The armature of the machine M^1 was normally open at the ring contacts, and could be closed either by connecting the ring or through an external circuit. Such a circuit was made to include the field coils of the machine M^2, and the armature of this machine was connected in the direct current circuit from the poles of the battery. Thus connected, the two machines moved as one; the machine M^2 following all the fluctuations of speed in the machine M^1, as if their armatures were carried by the same shaft, the speed being varied between wide limits. To convert this mechanism into a synchronizing device in

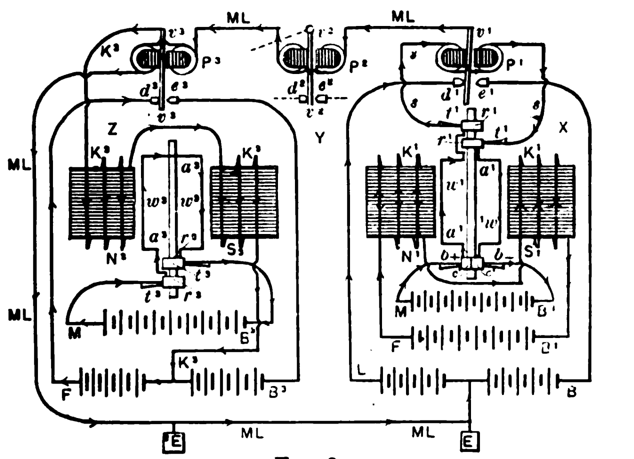


FIG. 2.

such a way that the machines could be placed at a great distance from each other was another step. As there was evidently an alternating current in the external loop connected to the armature of the first machine, the reversals of current in this circuit must correspond in time to the half revolutions of the armature of this machine, and an ordinary polarized relay connected in the loop would vibrate in unison with the half revolutions of the armature in the machine M^1. The second machine could therefore be made operative at a distance by simply connecting another relay in an independent line circuit and causing the latter to reverse the current in the second machine. This arrangement, which constitutes the fundamental synchronizing device is shown in figure 2. Here the first machine placed at station X has a polarized relay connected in the external armature circuit, and the relay vibrates in response to the

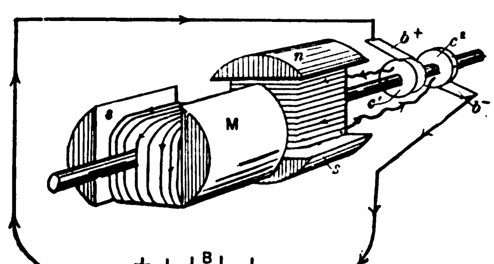


FIG. 3.

reversals of current in the armature of this machine, which correspond accurately to the half revolution of the machine at X. A line circuit extends from the fixed point of the relay vibrator to the distant station Z, where it includes the coils of another relay and returns to the middle point of the line battery L B at X, the opposite poles of which are connected to the contact stop of the relay at this station. From these connections it results that any relays in the line circuit will be actuated by reversed currents in unison with the half revolutions of the machine at X. At any distant station, as the one shown at Z, another machine has its field coils connected as follows: One terminal to the fixed point of the relay and the other to the middle point of a local battery, the opposite poles of which are connected to the contact stops of this relay, the armature of this machine being connected through ring contacts and brushes to an independent source of direct current. Connected in this manner, the two machines still move in perfect unison, even at variable speeds, though separated from each other by any line resistance through which a polarized relay can be made to act. With a single coil armature the driven machine is at times quite erratic, as it can evidently move in either direction, and I have seen such machines reverse instantly at a speed of several hundred revolutions a min

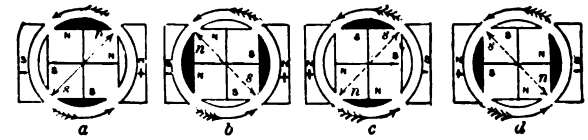


FIG. 4.

ute, and go apparently as fast in the opposite direction, and this even when provided with a fly-wheel of moderate weight.

This difficulty may be overcome in a variety of ways; an effective one is shown in figure 3, which represents a form now given to the armature of the driven machine; it has two coils in series connection, but wound with their poles at right angles to each other. This armature, being placed in a single field, I had supposed would move at only half of the speed of the first machine; but, on the contrary, the synchronism was perfect, the motion was continuous in direction and it has never been known to reverse. The analysis of its action is shown in figure 4, where the armature is represented in the four successive quadrants of a single revolution, the black and the white pole pieces representing the ends of the two coils in their different positions. The dotted lines indicate the position of a pair of resultant poles which must lie diagonally between the actual poles; this diagonal line represents the resultant polarity of the armature, and it is evident that neither of

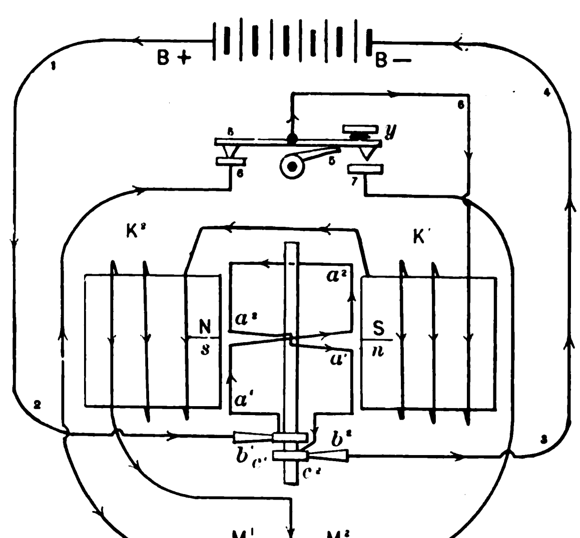


FIG. 5.

its actual poles could be in a position of stable equilibrium while in line with the poles of the field; the resultant armature pole is therefore made to follow a changing field that moves through 180 degrees at each reversal of the current.

Figure 5 illustrates an experiment made in determining

a suitable form of armature. A two-point key was used to reverse the field intermittently, the armature being supplied with an independent direct current. Even with this irregular alternation of the current the motion was still continuous. Another method of preserving absolutely steady synchronism is shown in the sketch figure 6. In consists in providing the driven machine with a single coil armature and a multipolar field; thus arranged the armature passes through a smaller arc of the entire circle at each reversal

FIG. 6.

of the field; but while the motion is steady it has the evi dent disadvantage that so high a speed cannot be obtained with the same number of reversals in a given time.

Such are the main features of the synchronizing device. There are numerous details which cannot be treated within the limits of a single paper. The uniform motion of distant machines is secured at rates of speed that may vary within considerable limits, and synchronism is maintained independently of the isochronous motion of any device or moving part, all the machines moving in unison with a govern-

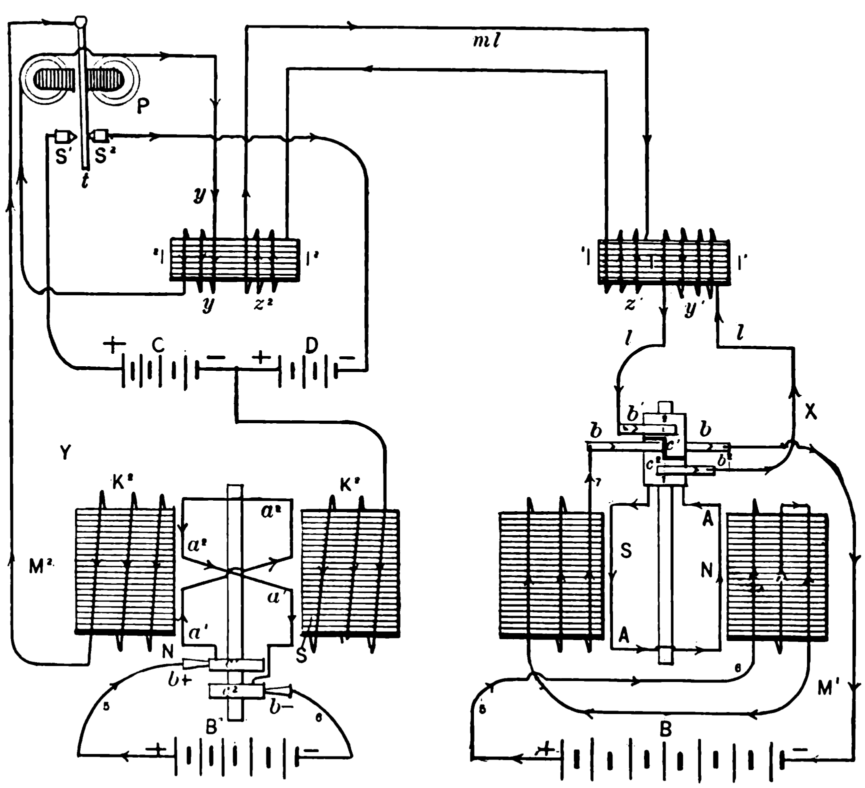


FIG. 7.

ing motor which sets the pace for all the rest. The controlling machine may evidently be any form of direct current motor carrying a revolving pole changer.

A practically constant speed is, of course, necessary in any application of this device to the telegraph, but as an illustration of the variable synchronism it may be stated that in a continuous run of 25 hours the speed of three machines, connected by a single line circuit, has varied uniformly between 100 and 1,000 revolutions per minute. Figure 7 illustrates a modification of the original system in which induced currents of high E. M. F. are used as synchronizing currents. The armature loop of the governing machine is connected to the primary of an induction coil, the secondary to the line circuit at distant stations, the impulses are reconverted and caused to actuate a polarized relay as before.

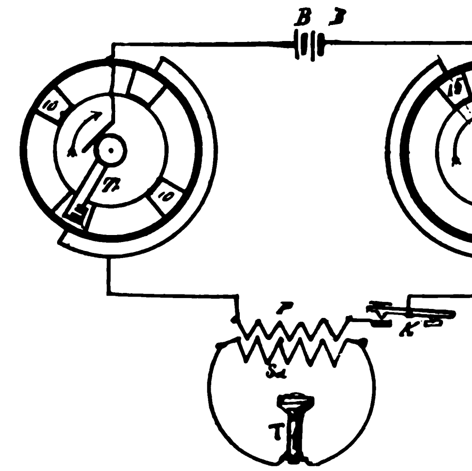


FIG. 8.

A simple experiment made to determine the accuracy of the synchronism will be explained, as it led directly to a separate application of the systems to the transmission of signals. The connections are shown in figure 8. From the battery B a line extends to the spindle of the two machines, each provided with segmental distributors of 48 parts. From one such segment in the machine M^1 a wire was taken to a segment of the other machine, the primary of an induction coil and a key being connected in this line; the secondary of the coil was connected, as shown, to an ordinary telephone receiver. If the machines were moving in unison the circuit of the primary would be completed whenever the revolving trailers were simultaneously upon the connected segments in the two machines, and the key was closed. If either trailer were slightly in advance of, or behind, the other, there could be no primary circuit formed on closing the key, no induced current, and no sound in the telephone. The machines were driven at variable speeds, and the wire at one machine was moved from one segmentto another, until the particular one was found that corresponded to the one selected in the first machine; the telephone then responded accurately to every revolution, thus proving the synchronism perfect within less than the breadth of a single segment. Other wires were then connected to other segments with a like effect.

A singular and unexpected result was deduced from this experiment. Evidently the machine M^2 might start into synchronism at any point of the circumference, the trailers making any angle with each other, as the one shown in the diagram. A revolving switch had been provided, which was so arranged that by turning it a wire could be moved from one segment to another, and so adjust the circuits independently of the relative positions of the trailers. The machines were repeatedly stopped and started again, but

came again into synchronism always at the same point, the wires never requiring any adjustment, establishing clearly the singular fact that the driven machine always went into synchronism at the same point, and could, therefore, be made to start in at any point of the distributor by

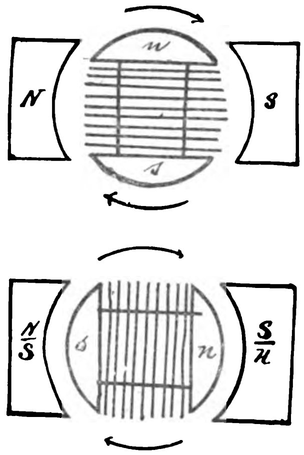


FIG. 9.

a proper adjustment of the trailer on the spindle. The reason for this may be found by considering the relation of the forces as expressed in the diagram figure 9. Here

X and Y are connected to the line M L, as shown in figure 2. The synchronizing current is constantly maintained upon the line, and is made to serve also for transmission of signals. It will also be observed that as the armature of the relay at X puts opposite halves of the line battery to earth alternately at each half revolution of the machine at X, one-half of the circumference of the segmental distributor corresponds to the transmission of positive and the other to the transmission of negative currents to line. Thus while the trailer is sweeping over one-half of the distributor, one part of the line battery L B is connected to line and earth, and while traversing the other half of the distributor the other part of the battery will be in circuit, each in turn sending a succession of impulses of opposite polarity. Some arbitrary line as Q^1 U^1 may, therefore, be drawn diametrically across the distributor at X, and on one side of this line positive, and on the other negative, currents will be sent to the line wire, and by making the distributor movable about its axis the line Q^1 U^1 may be made to fall within the broad spaces $E+E-$. The distributor is composed of two parts, one designated $E+$, and $E-$ is connected directly to earth; the other consists of a series of insulated segments, 1, 2, 3, etc., in opposite quadrants of the distributor. Whenever the trailer is on the parts $E+$, $E-$, the battery has a free path to earth and line through the trailer Tr^1. The insulated segments are connected to the local branches in pairs, each local branch having at least two such segments diametrically placed in opposite

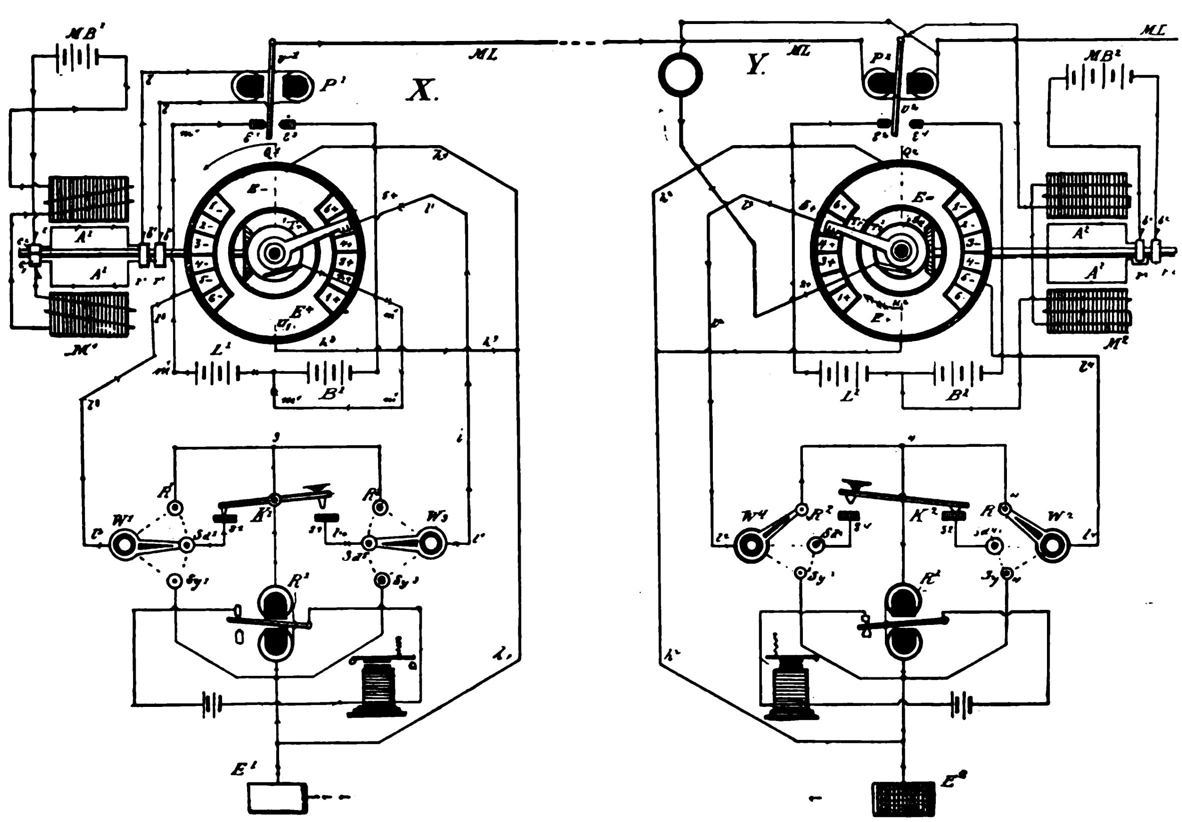


FIG. 10.

the same machine is shown with the armature in two positions, differing by 90°; the first is a position of maximum effort, while the second is a minimum, as the field poles are changing to the opposite designation indicated by the lower letters. As the machines are provided with fly wheels of considerable weight, the point of maximum effort shown in the upper diagram is the one at which the machines most readily come into synchronism with each other, being the point of least opposed mechanical resistance. In figure 10 is shown the simplest adaptation of the synchronizing device to a system of telegraphic transmission. The motors

halves of the distributor. The connections and instruments in circuit are alike for all the branches, and are, therefore, shown in detail for only one.

Each branch—say that of operator No. 5—has a double line to earth taken from opposite halves of the distributor, as those shown at 5 + and 5 —. These branches are connected to a three-point switch W^1 and W^3, which may be turned to R^1 and R^3 for receiving, or to S^1 and S^2 for sending, thus throwing the key in circuit, or to sy^1 and sy^2 for synchronizing, thus leaving the sending and receiving apparatus out of circuit. An ordinary reversing key is used,

the relay circuit being connected to its middle point. The drawing represents station X sending and Y receiving. Thus, if the key be depressed, as at Y, so that its front contact puts the line to earth, intermittent pulsations of one polarity will go to line, corresponding to the contacts made by the trailer with the segment pertaining to this branch on the right hand side of the distributor at X, while the negative currents, corresponding to the left hand half of the distributor, will be cut out, and the corresponding relay at both stations will be actuated by currents of constant polarity. If, now, the key be reversed, the trailer, on reaching the opposite segment, 5 —, will send an opposite current to line and earth, causing the polarized relay to reverse in accordance with the motions at the key; hence signaling may be effected with a sounder connected in a local circuit as shown. Thus, if the key were closed at both the front and back contacts at the same time, the receiving relays would all vibrate in unison with the synchronizing relay in the line circuit, and transmission is effected by cutting out all the positive or all the negative impulses, according to the position of the key, whether on its front or back contact. With a slow speed the contacts connecting any branch to the main line must of course be increased to insure certainty of action; but with a sufficiently high speed few contacts will be required. In the foregoing system the synchronizing current, which is only used as such at two points during each revolution, is made to answer for signaling purposes also.

There are, of course, numerous details incident to such a system that cannot be dealt with in a superficial description. Each operator's circuit being made up with a number of rapid contacts with the main line, each one of the ordinary Morse characters is necessarily made up of a number of pulsations of current, and the serious problem has been to construct a relay that would respond to these broken currents. A single polarized relay has a tendency to leave its contact during the breaks. A number of devices have been made to correct this. One such device is a sort of locking relay. From the opposite segments on the distributor the branch circuits go as before to the contacts of a two-point key, but each through the coils of a separate relay, either of which has its armature attracted according to the position of the key, Either armature on being drawn up becomes locked by an auxiliary magnet, and held in this position so long as the armature of the other relay is against the back stop through which the locking circuit is closed. On reversing the key the second armature is momentarily drawn up, and is locked in the same manner by the armature of the first, which is then released. Numerous other devices of a similar character have been used, which cannot be explained in this paper. Figure 11 shows by a diagram of circuits a modification of the system of single wire transmission, in which superposed currents of high tension are used to actuate the receiving apparatus, thus making it independent of the synchronizing current. The key is so arranged as to open and close the primary of an induction coil, the secondary of which is connected to line. A telephone or similar receiving apparatus, arranged to respond to currents of high E. M. F., is connected with a receiving circuit instead of the relays. With such a system of transmission a higher order of multiplex transmission can be obtained than with ordinary receiving apparatus; and it requires so little current to actuate these instruments that each operator can work a circuit with a far less number of segments. As the trailer makes contact with any particular segment there will be, of course, two currents sent, due to the make and the break. In figure 12 is shown an arrangement by which the first of these is cut out. The primary of the induction coil, connected through a separate trailer and series of segments, is closed by the key before the trailer connected to the line circuit has reached its segment. The induced current due to the break only is then transmitted to line. This device is shown in figure 12, and, as there indicated, it has also been made to work polarized relays suitably wound for these high tension currents.

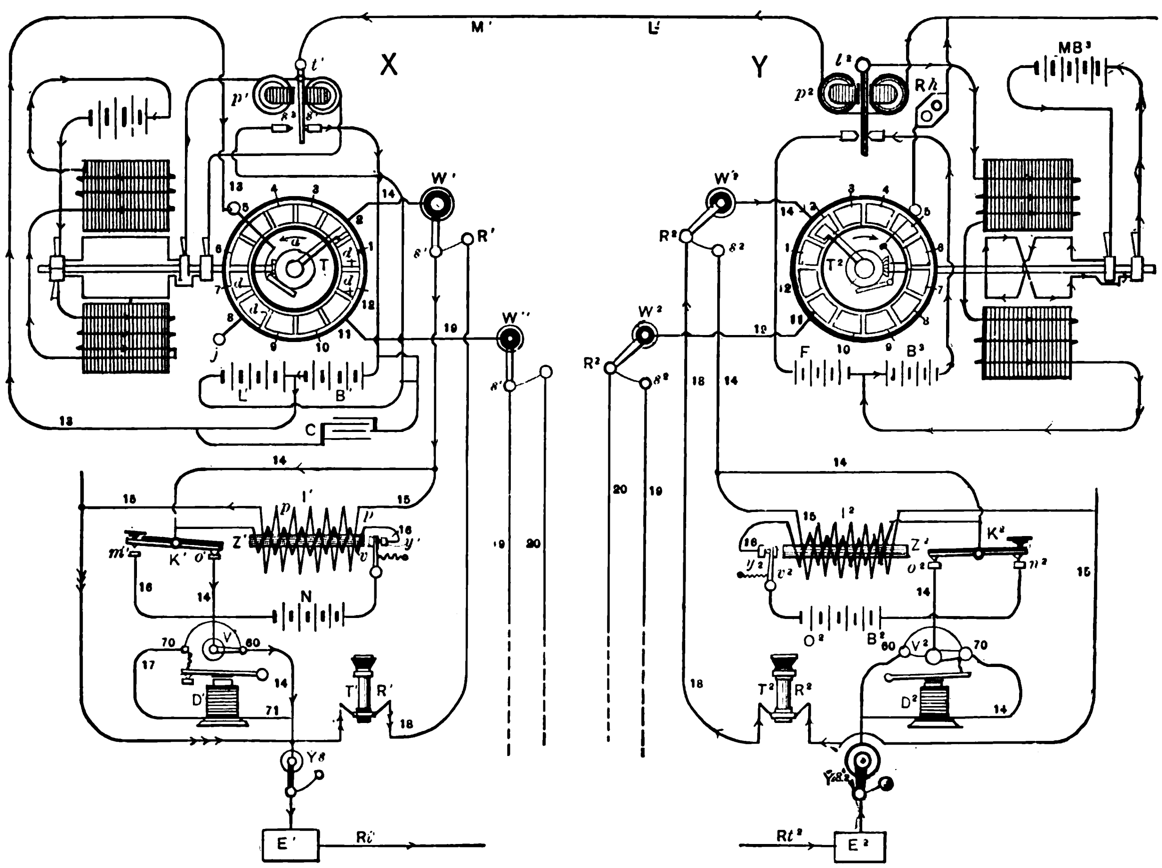


FIG. 11.

The general subject as a system of telegraphy will be recognized as a rather extensive one for a single paper. I have given the details of a few of the more decisive experiments that have been made, and I have confined the paper to what has actually been accomplished. With reference to practical results on a line test I shall have more to say at a later day. A technical paper, at its best, is uninteresting, and the present one is already long. In closing, I will answer a pertinent question that may occur to many: Of what use is a system of multiplex telegraphy?

The answer is this: We live in an age of industrial advancement. People are no longer satisfied with what is good enough. They want the best. The best rail for roads must be made of steel, and, this fact once established,

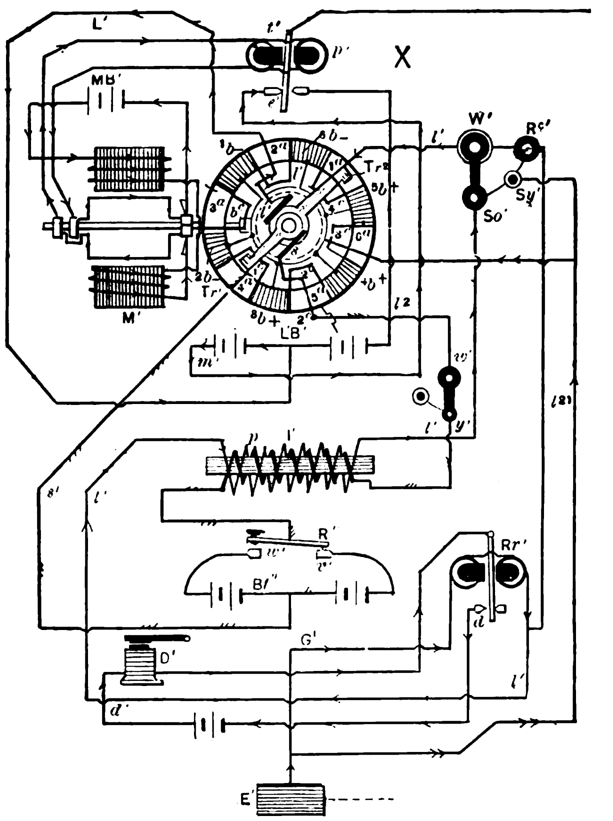


FIG. 12.

iron was no longer suited to the requirements of travel, and iron roads have been turned into steel ones. The steel rails bear the same relation to iron in the systems of transportation that the copper wire does to the iron one in systems of telegraphic communication. The higher rate and more reliable service required demanding already, in a large degree, the substitution of copper for iron wires on the main lines of business. With a good copper wire and a reliable system of multiplex transmission, a single wire from New York to our principal cities would meet all the requirements of business, and it is no exaggeration to say that with these conditions given the existing system of intercommunication by the telegraph could be duplicated at a cost of one-tenth the present amount of capital invested by either the government or private enterprises. That is what copper wire and multiplex telegraphy mean, and it is doubtless the reason why so many find the subject worthy of their best endeavors.

.... SPECIAL dynamos are now made which will, with an expenditure of 100 h. p., precipitate 18 tons of copper per week. The impure metal is made to form the anode in a bath of sulphate of copper, the metal being deposited in a pure form on a thin copper cathode.—*W. H. Preece.*

ELECTRICAL ENERGY DIRECTLY FROM SOLAR RADIATION.

BY PROFESSOR I. THORNTON OSMOND.

THE dynamo has an efficiency which is above complaint. Its fatal defect is its necessary connection with the steam engine. The steam engine has an efficiency which is very objectionably low, and, in the nature of things, this is absolutely irremediable. As the work agent of the world, the steam engine, inestimably great as its service has been, is no longer tolerable, except of necessity, until its successor arrives. Instead of thermal energy, electrical energy is to do the work of the world. This requires a simple and cheap means of unlimited electrical supply by apparatus or processes entirely independent of the steam engine (or any thermic engine) and the dynamo.

The cheapest supply of energy, the most universal and the most unlimited, is from the very source, the solar radiation. What is required, then, is an inexpensive apparatus and process for obtaining this energy in electric currents; call it a *helierg*. This, with a fairly perfected storage apparatus, science and invention must give to the world before long.

In considering possible methods of obtaining electrical current directly from solar energy, in November of 1886 I was led to study Faraday's discovery of the rotation of the plane of polarization of light by magnetic forces, and Maxwell's electro-magnetic theory of light. It seemed to me probable that this might be the way to accomplish, or to find how to accomplish, the desired result. Should not *the rotation of the plane of polarization produce magnetism?* Faraday certainly expected that electricity would be obtained in some way directly from light. "What the possible effect of the force may be in the earth as a whole or in magnets, or in relation to the sun, and *what may be the best means of causing light to evolve electricity and magnetism*, are thoughts continually pressing upon the mind * * *." Exp. Res., xix series, 2,242.

Soon afterward I devised a series of experiments for testing this matter, but I was prevented from doing more than sketch some apparatus until the ensuing spring. I then performed some of the following experiments, and others of them later.

I constructed a polarizer of a bundle of thin sheets of glass, set in a tube at an angle of 35° 25′ with the axis, giving a transmitted polarized beam about five centimeters in diameter. The tube was rotated by a belt from a wheel, a beam of sunlight being sent through it from a rude heliostat.

Three coils, from 18 to 63 cm. long, with different amounts of wire, and of different internal diameter, were fitted with soft iron tubular cores, with glass plates covering the ends. These were for holding vacuum, air, liquids, etc., to be traversed by the beam, whose plane of polarization was being rotated by the polarizer.

The following are some of my series of experiments:—

(*a*) Try whether an astatic needle, silk fibre suspension, placed axially in the rotating beam, is deflected; the same, placed at right angles to the beam.

(*b*) Try, with astatic galvanometer, cutting the rotating beam variously by a loop of wire connected to galvanometer.

(*c*) Try several meters of wire lying in (along) the rotating beam, with the ends connected through the astatic galvanometer.

(*d*) Try several meters of wire, as in (*c*), but with ends attached to quadrant electrometer.

(*e*) As (*c*) and (*d*), but using an electro-dynamometer to see whether an alternating current is produced.

(*f*, *g* and *h*) Try passing the rotating beam through the different coils, with air, water, carbon disulphide, etc., and using galvanometer, electrometer and electro-dynamometer.

(*i*, *j* and *k*) Try the above with arrangement for alternately admitting and cutting off the beam, either rotating or at rest.

l, *m*, *n*, and some other experiments, I will not at present describe.

(*q*, *r*, *s*) Try a coil of wire wound longitudinally on a bar of iron, 2.2 m. long, 2.5 cm. square, with astatic galvanometer, quadrant electrometer, and dynamometer.

(*t*, *u*, *v*) Try a coil of wire wound longitudinally on a wooden bar, 2.5 m. long and inserted in an iron water pipe, with astatic galvanometer, quadrant electrometer, and dynamometer.

These experiments were made in the second story of a five-story building (above basement), used for dwelling houses, dormitories and general college purposes. The apparatus, except the astatic galvanometer and quadrant electrometer, was very rude. The polarizer is but partial, the means of rotation very inadequate, and the continual jarring of the building renders certainty as to small action of galvanometers, etc., impossible.

The result is, (1) My work proves that there is no opto-magnetic or opto-electric action of sufficient magnitude to be certainly discoverable, with such apparatus and under such conditions as I used, by methods (*a*) to (*k*), inclusive. (2) It is far from disproving such action.

In fact, I believe in two or three of the experiments there was indication of slight electric action.

I hope to have within a year better conditions for work in the Physics building (Pennsylvania State College), now under roof, to reconstruct some of my apparatus with greater efficiency, to add some, and with improved conditions and means to re-try some of these experiments more decisively, and to continue the research by other experiments.

Papers Read Before the National Electric Light Association, Chicago, Feb. 19-21, 1889.

DISRUPTIVE DISCHARGES IN LEAD CABLES.

BY C. H. RUDD.

In coming before the association at this time with the subject named, my principal object is to consider the experiments of A. G. Acheson. An account of these experiments appeared July 7, 1888, and was enlarged upon by Mr. Acheson at your last meeting. The results of the investigations suggested two conclusions :—First, that the static capacity of a cable is a transforming agency by which a passing current might develop a static charge of greater electromotive force than the electromotive force which produces said current ; Second, that a static charge

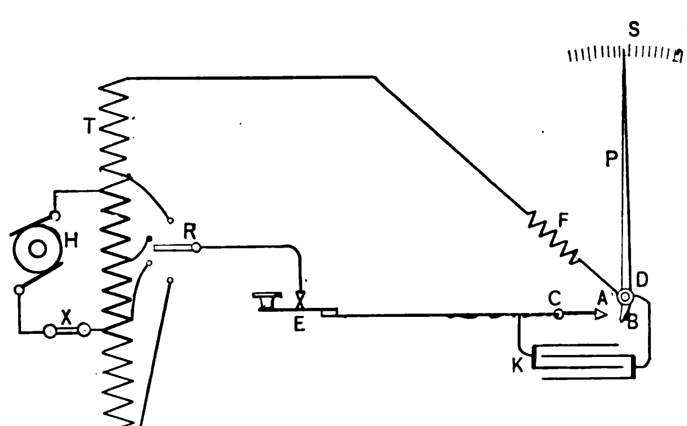


Fig. 1.

will not pass an arc. These conclusions are radical and cannot fail to attract attention. If they are sound they have a most important bearing upon cable service. By virtue of the first conclusion, we would be obliged to largely increase the value of cable insulation, or else put on high pressure protectors of a nature to carry a constant stream of sparks. And we would be obliged to ask, why have we not had a much greater number of burn-outs than we have? By virtue of the second conclusion, the high pressure protectors, if used, would have to go into every section of cable cut off from other sections by lamps. I do not believe these conclusions to be sound, and expect to show that they are not. I question the first because it conflicts with the well-known law that the electromotive force of a static charge cannot exceed the electromotive force of the charging source. This law is as well sustained in daily practice as is Ohm's law. If the results of an experiment point to the overthrow of a long-established principle, the experiment itself will bear inspection.

Let us look at the experiment from which the first-named conclusion was drawn. Figure 1 is an exact copy of Mr. Acheson's first diagram. H is an alternating dynamo. T is a transformer, in which a portion of the wire is used for both primary and secondary. R is a switch to aid in obtaining different degrees of pressure. E is a switch with which to break the secondary circuit. X is a switch with which to break the primary circuit. C and D are posts supporting points A and B. The distance between points A and B is adjusted by means of pointer P and scale S. F is a piece of fusible wire for safety. K is a condenser. Now, let us suppose condenser K to be disconnected for a moment. It was in that form that the first step was taken. We are told that by rupturing the circuit at E, sparks were obtained between A, B, of various lengths according to the position of switch R. This is plainly impossible. To open switch E is but another form of increasing the distance between A, B, and we know that such increase would not cause a spark at A, B. I do not deny that sparks were obtained in the experiment, but I do deny that sparking conditions are shown in this diagram. There are no explanations offered by which the sparking conditions can be understood, and explanations would be valueless in this case, for if the sparks occur in any roundabout way the experiment becomes simply an electrical puzzle without bearing upon the subject under consideration. The investigator seems to assume that everybody will agree that ruptures of circuit and sparks are inseparable. This assumption is without support. When ruptures

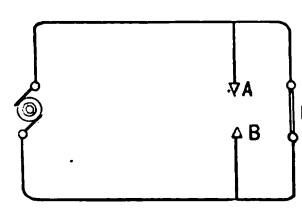


Fig. 2.

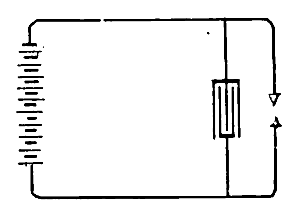


Fig. 3.

produce sparks it is because accompanying conditions are favorable, for instance : If a closed circuit is relieving two points of electrical strain (see points A, B, figure 2) and the circuit should be ruptured, say at E, points A, B would have to bear the strain and a spark might pass between them. We do not find such tendencies to spark in the work shown. From the nature of the investigation it is manifest that the first step in the experiment should have been to produce sparking conditions such that the sparks would depend on pressure only, after which the effect of adding condenser capacity could have been properly observed. Inasmuch, then as the experiment shown to us lacks the vital element necessary to make it demonstrative, every deduction made from said experiment must fall to the ground. The subject under investigation by Mr. Acheson is treated of by Gordon under the head of secondary condensers. A secondary condenser (see figure 3) is said to add to the burning power of a spark. If Mr. Acheson had made a proper series of experiments in the laboratory and had then desired to carry his work over into practical life, he would have first obtained a cable carrying heavy current, the

cable having in it a spot so weak that the direct pressure was able to break through. In such a case he would have sparking points around which he might connect his secondary condenser, and observe its effect upon the burning power of the spark. He would, however, require some sort of electrical microscope with which to make his observations. That any ordinary method of noting the effect of a condenser upon the spark which I have described would be of no value, is manifest when we consider that a condenser of one microfarad charged to a voltage of 2,500 would hold .0025 coulombs. A current of one ampere carries one coulomb per second. As it is, coulombs which determine the destructive power of a spark, it is plain that when direct pressure begins to break through a weak spot in the cable, the addition to its destroying power, which it receives from the condenser capacity of the cable is extremely insignificant. To sum up my position concerning Mr. Acheson's first conclusion, I will say that the static charge in an ordinary cable is a negligible quantity when compared with the regular current flowing, and the electromotive force of said charge cannot be greater than the electromotive force of the current from which it was derived. Therefore, in considering the character and thickness of insulation, we have nothing to take account of but the primary pressure which bears upon the insulation. Mr. Acheson's second conclusion, viz., that a static charge will not pass an arc, virtually declares an arc circuit to

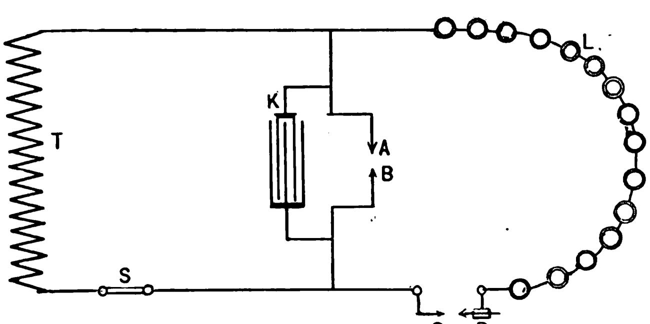


Fig. 4

exist as a number of sections in a sense insulated from each other, and in that connection the statement is made that each separate section comes under separate strain every time that the circuit is shut down. I think that I have already satisfied you that we may hold our old ideas concerning the electromotive force of a static charge, therefore we need not fear that an imprisoned charge would do any more harm than the current did from which it came. If we charge an ordinary condenser from a battery, and the condenser does not break down, we do not apprehend that the condenser will break down when we disconnect the battery. There is in the minds of some people an idea that static electricity when it begins to move produces a current possessing different properties from currents formed by other electricity under the same conditions. This idea is unsupported, and need not be entertained seriously.

But let us see how Mr. Acheson proves that a static charge will not pass an arc. In figure 4, T is a transformer yielding 2,067 volts. S is a break switch, K is a condenser, A, B, sparking points, C, D, adjustable points so arranged as to be readily placed in contact, L a circuit of 20 incandescent lamps in series measuring perhaps 4,000 ohms all told. Mr. Acheson says that when contact was made between C, D, no amount of rupturing circuit at S, could cause a spark at A, B, but when he opened points C, D, and produced an arc there, then rupturing circuit at S, produced a heavy spark at A, B. From this the conclusion is drawn that the arc is an effectual barrier to the passage of static charge. Let us see. If we have an arc burning at C, D, it would expire simultaneously with the arc which would form at S, when S is opened. Therefore, the retardation spoken of by Mr. Acheson was due to the break at C, D, and not to the arc at all, the arc having expired before the observation on retardation was made. To sum up my position as regards the second conclusion it is evident that the arc affords free passage to ordinary currents, and we have nothing to indicate as yet that the arc makes distinction between the static charge in motion and other electricity in motion. It is also evident that the insulation of a cable does not undergo strain at shutting down due to the static charge. Mr. Smith referred at the last meeting to some sparks observed when an arc circuit was shut down. These sparks may be readily ascribed to magnetic discharge from the lamps.

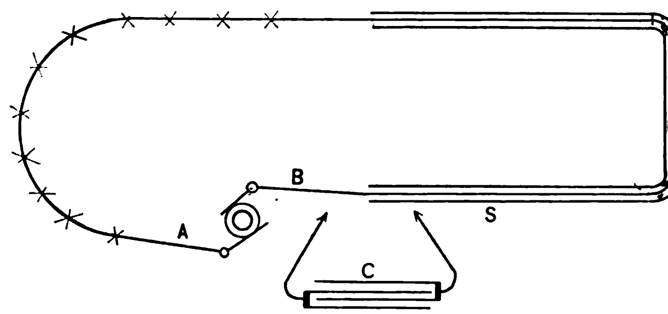


Fig. 5.

I will now speak of an experiment in which I assisted last summer. The experiment is one which Mr. Sunny described before this association in August, 1888 ; 1,000 feet of lead-covered cable was laid out upon an ordinary dry floor. This cable was connected as a loop into a working circuit. When first connected up, condenser C could be strongly charged by placing it in circuit between B and S, figure 5. At first sight it seemed that Mr. Acheson's position was confirmed. An attempt to repeat this experiment on the following day resulted in failure. Another attempt on the third day succeeded. I arrived at this stage of the proceedings. Upon examination I found that different working circuits had been used each day. The leading idea in the experiment was that if a current would create a static charge of a nature unlike said current, the results should be obtainable from any working circuit. When I learned the conditions of the various experiments, I affirmed my belief that the results obtained were of the most commonplace nature, and requested that the steps in the experiment be repeated. This was done. We found that when we put the extra cable into a circuit entirely under cover scarcely a sign of charge could be seen in condenser C, but upon plugging into a circuit exposed to the weather, a definite charge was obtained. We then returned to the covered circuit Results were same as before, viz., no charge. We then put a ground at A. This gave us a strong charge. We then began to observe the polarity of charge, and found that we could reverse the polarity by putting the loop in at A, and the ground at B. This change removed all ideas that the results obtained were out of the ordinary, and let us square down upon the common principles of everyday life. The shield S was a ground of some value, so we concluded that we had been trying to see if we could get a charge out of a working dynamo by connecting a condenser between A and the ground with a ground at B, and again if we would change the polarity of the charge by putting the condenser between B and ground with ground at A, figure 6. A rather simple experiment when stripped of its useless features.

In conclusion, I will say that if disruptive discharges occur in properly insulated cables, we must look for the cause in those sources of high pressure which exist in nature. I do not believe that burn-outs can be ascribed to any one cause, but that each individual case has its own individual cause. In practice we must provide insulation strong enough to meet the daily strain, and suitable devices to prevent the accumulation of charge from outside

sources of greater pressure than the insulation will bear. As yet we have no proof that high pressure protectors are required anywhere outside of the station from which the wires start. Mr. Acheson says that the greater number of grounds or burn-outs occurring on arc light circuits are at the terminals of the lead or at the joints, and says that such a state of things would be naturally caused by the greater density of the static charges at these points. This

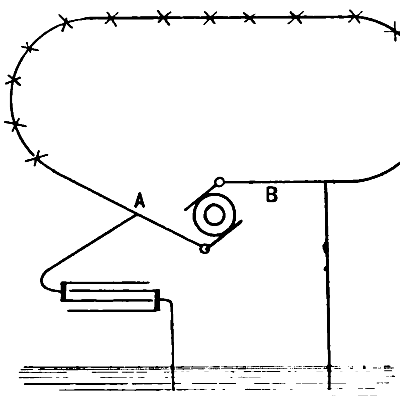


Fig. 6.

statement strikes me as a singular carrying over of ideas obtained in laboratory work with purely static electricity and arbitrarily applying them to entirely different conditions. The natural static charge in a cable, due to the distribution of the working electromotive force of the current in the cable, must necessarily be governed in its distribution by the force from which it originated. The shape of the conductor cannot act in the matter of this kind of static distribution, as the shape of an insulated conductor would act upon a purely static charge. This remark of mine about distribution may not be treated of by any of the men who write books, but I confidently appeal to my hearers for support. As regards burn-outs occurring at terminals and joints, we know that great care is required to make these points equal to the rest of the cable in matter of insulation. I do not see how it can be known that burn-outs at such places are not due to accident in construction or actual neglect on the part of the workmen.

ELECTRIC LIGHT STATIONS AS FIRE RISKS.

BY S. E. BARTON.

(Abstract.)

THROUGH stress of circumstances my paper will be short, but I wish to touch both subjects in a general way.

Insurance companies, like yourselves, sometimes get involved in litigation, and it is my unhappy lot to have been drawn into that unfortunate condition, to the exclusion of almost everything else, for the past two months. I offer this information as a preliminary apology for what may follow.

I cannot refrain in the outset from congratulating myself, and my insurance associates in New England, upon the very cordial relations existing between ourselves and the electric lighting interests, and also upon the very favorable experience the underwriters of New England have met with in having comparatively little loss to pay on account of the electric lighting fire hazard. Nor can I refrain from saying that, as favorable as our experience has been in the past, it is being, and will continue to be, made much more favorable through the good work undertaken, and being carried on through the New England Electric Exchange. Its influence and results tend in the right direction—to the education of those employed in electric lighting pursuits as to what practices and work are safe and what are not, and to the exclusion from such pursuits of any who may, through lack of proper scientific knowledge, be unqualified for the positions they hold.

As a matter of fact, however, I believe that the experience has been, that because men have been required to provide themselves with a license certificate as to their qualification, they have speedily and earnestly set themselves to work to gaining the necessary technical knowledge to qualify them to receive the certificate. It goes without saying, I think, that those men are thereafter more capable in their business, and safer men for all parties concerned than they were before.

We having on the one hand an element so fraught with hazard, and on the other one so easy of control, your duty is obviously to do all you can by your own work to promote and secure safety, and to encourage all feasible plans and efforts of others tending in the same direction. While the plain duty of underwriters in the public interest is, first to hold to a strict line of requirements any of you who may be tempted, through competitive pressure, to depart from what you know are safe practices, the underwriters' duty is not fulfilled until they have indorsed electrical illumination and power by the reduced premium charges that such combined action on the part of electrical and insurance interests is sure to warrant.

The two interests are peculiarly identical. Hand in hand they can accomplish much in reducing the enormous fire waste. Disunited and antagonistic to each other, your work will be slower in development. Competition among yourselves and no restraining supervision on your part will drive you to cheaper construction and maintenance of your work. More fire loss and higher premiums for insurance must inevitably be the result, while the public, still calling for your light because it is good, will be deterred to an injurious degree by reason of the increased insurance rates that will surely follow, such as have already been applied in some cases and threatened in others.

The policy of insurance companies and organizations toward electric lighting or any hazard, in fact, capable of being minimized, should not be "to fit the punishment to the crime," but rather to lessen the crime, or endeavor to. In your case they will be loth to undertake that policy without your co-operation, and can succeed only with it. Without their co-operation, I think you would make but little headway in that direction.

In New England electric lighting is very popular with insurance men, particularly since it has, as applied to some risks, been included in the schedule of "improvements" for which a reduction in tariff is made. The energetic agent in his efforts to scoop in his competitors' pet risks does not fail to recommend the introduction of electric lights as a means of procuring a lower rate and securing the risk to himself. He thereby becomes your solicitor. He goes still further; in many cases he manifests his favor to you and serves his own interests by becoming an investor in your apparatus, and a promoter of your industry. Such a condition of things is but the natural outgrowth of a perfect harmony and co-operation between the two great interests. It ought to exist throughout the land.

By reason of faulty work which crept in during the early stages of electric lighting in Boston, numerous small fires which have occurred there have created a scare among insurance men, causing a threatened increase in rates unless a remedy was applied. The following notice just issued by the Boston Board of Underwriters indicates where they look for relief:—

"At a meeting of the Underwriters' committee, held January 28, 1889, it was voted that on and after May 1, 1889, all electric lighting and wiring companies' men, who are in any way responsible for any of the wiring, running, of dynamos, or care and management of batteries for electric lighting, must hold a license from the New England Electric Exchange. This rule applies to isolated plants

and central stations alike, and is imperative. No exception to it will be made."

Such a rule may seem arbitrary to anyone not in sympathy with the objects sought by the "Exchange" (and there will always be found some objectors to any good movement), but after all I believe it is just the medicine needed for the complaint.

In regard to the electric light generating station, the situation is not a pleasing one to either party. Out of over 200 fire insurance companies doing business in Massachusetts, the electric light station is a prohibited risk with all but about 25 or 30 of them. The reasons for this interdiction are chiefly these: First, because electrical apparatus, and dynamos in particular, have been found to be very susceptible to large and uncertain damage, in cases of small fires; secondly, because generating stations have too frequently been crowded into very hazardous and improper quarters, simply to get floor space and power at the smallest cost, without regard to permanency and ultimate results; lastly, and mainly, because insurance men as a rule, do not understand the nature of the hazard and often fail to get enlightenment from those in charge of stations. Therefore a large majority of the companies adopt the course of all wise underwriters,—they "take the benefit of the doubt" and leave your station risks alone.

Judging from my own observation of the way in which electric light station risks are peddled about to find takers, and the rates that are charged by reason of their being so few takers, I am led to believe that the question of insurance is to many of you an unsatisfactory one. I cannot help thinking that, even with the present condition of stations as fire risks, if the business as a whole were so classified as to show the aggregate premiums on the one side, and the losses and expenses of doing the business on the other, a fair margin of profit would be shown. But no such general classification or account is made, and the experience of those few companies that venture on your risks, if favorable, is carefully kept to themselves, so that others may not be induced to venture.

Perhaps a bureau of the National Electric Light Association might be formed, the purposes of which would be to collect information as to the aggregate premiums paid and losses incurred in central station insurance. If such a labor should demonstrate that a fair profit remained after deducting gross losses and expenses from gross premiums, probably modified rates and a freer acceptance of the risks would follow. If it demonstrated that the present high rates of premium yielded no profit to those companies insuring your plants, then you would be convinced of something radically wrong, and you would have before you a field for investigation and a work of much needed reformation.

Maybe an Electric Light Mutual Fire Insurance Association would solve the question; but such a step should be taken with caution, and should be guided by those well-founded principles and practices that have proved so successful with the Manufacturers' Mutual Fire Insurance companies of New England, and of which C. J. H. Woodbury (well known to many of you) is a prominent officer. No risk should be accepted by such an association until improved to a certain standard as a fire risk, and then regular quarterly or tri-yearly inspections should be made, to see that the standard of equipment and care in operation were maintained. Much valuable information as to improved modes of construction and equipment could be disseminated by such an association, or even by your own association.

Surely the capital invested in generating plants would seem to warrant some general action looking to the standardizing and maintenance of them, and their insurance at a moderate cost.

.... Our first duty is absolute obedience to the law of nature in the construction of any machinery whereby we propose to convert a pound of coal into horse-power.—*E. N. Dickerson.*

FUEL OIL.

BY S. S. LEONARD.

(Abstract.)

During the past few months I have endeavored to obtain what information I could upon this subject from those who have been using oil, and especially from any electric light companies. The general experience does not seem to be very favorable, and I have been advised to have nothing to do with it; that the saving by its use over other fuels, if any, was more than counterbalanced by its injurious effect upon both boilers and furnaces; that the fire risk was greatly increased, and it would be found very difficult to place insurance upon our plant. One gentleman wrote me that he had just had a serious fire in his station, which could be clearly traced to the use of oil, and then kindly offered to sell me his outfit very cheap, should I desire to find out for myself, what they already knew, that oil was a failure. Others found that the use of oil was injuring their boilers by burning out the flues; some reported that it was almost impossible to keep their furnaces in repair, the cost of repairs amounting to more than was saved by the use of oil. As I read over these various experiences it carried me back to the time when we were going through the same trouble. Although we never injured our boilers, we did burn up a great many fire brick, and were obliged to rebuild our furnaces several times. Previous to experimenting with oil, I visited the East, and saw natural gas in use. I was impressed with its advantages, and when fuel oil was mentioned I thought I saw in it a substitute for natural gas. We were assured it was not necessary to alter our furnaces, but only to cover the grate bars with fire brick, put in the burner, turn on the oil, light it, and "let her go." I was delighted; but, alas, my expectations were not to be so easily realized. The oil was not all burned, and ran down into the ash pits, where it was set on fire; everything was dirty, and the odor was not agreeable. Notwithstanding all this, we still had some faith, and kept at it, and are now convinced that to make a success of burning oil for steam purposes it is as essential to have the proper settings or furnaces as it is to have a boiler to make steam.

We have been using oil for about eighteen months, and for the last six months exclusively under our seven boilers. The boilers are 14 x 60 inches, with forty-four four-inch flues. During the first part of the night these boilers are all in use, furnishing steam to four Reynolds Corliss condensing engines, from which we are using about 1,100 h.p. The steam pressure is easily maintained at any desired point, usually with us at 100 pounds. Our arrangement for the handling and storage of this oil I described in my former paper, and I only wish to add that so far it has worked admirably.

In speaking of the economy from the labor side, I made the statement that one man could attend to from seven to ten 150 h.p. boilers, which I am now positive of, as we have but one fireman at night and one during the day, while when using coal we had three men at night, and three or four during the day. It kept two men busy half a day wheeling out the ashes, and the other half was occupied in getting in the coal, and it was as much as one man could do to keep the flues clean. Now there are no ashes to cart out and no coal to cart in. Our flues are cleaned out once a week, and from the whole seven boilers there is not as much dirt as from one boiler with one night's run on coal. I am frequently asked if the burning of oil does not injure the boilers. A short time since the inspector of the Hartford Steam Boiler Insurance Co. made a very thorough inspection of our boilers. This same inspector had examined them a number of times when we were using coal, and was familiar with their condition previous to the introduction of oil; in reply to my question, "Did you discover anything wrong?" he replied that he thought they were in better condition than when we were using

coal. Our engineer has also examined them very carefully, and up to the present time has been unable to discover any evil effects from its use, so that from the length of time we have been using oil, and as no injury is apparent, I feel warranted in saying that the proper use of fuel oil will not injure a boiler. Improperly used, and by this I mean where the flame is allowed to strike the shell in any one spot continuously, it will soon damage a boiler, and the harder it strikes the sooner the damage; but this is true of any fire, whether it be coal, wood or gas; for, if the fire is blown against the shell as an oil fire is blown, it is only a question of time, and that not long, when the effect will be very apparent. By the proper adjustment of the burner this trouble can all be obviated, and the flame carried beneath the boiler, not up against it. I have already mentioned the expense of keeping in repair the settings or furnace as experienced by some who have used oil; this should not be, and is all wrong. We have furnaces that have been in use over a year, and they are in as good condition as when first built, and, as far as I can see, will last for a long time yet. Oil is very much easier on them than coal, is what our experience teaches. In reference to the burner, I would say that its requirements are few, but they are absolutely necessary to complete the success of using oil. It should be so made that it can be easily taken apart for cleaning when necessary; the oil should be all consumed that passes through it, whether the fire be a slow one or the burner pushed to its utmost capacity. It should not smoke, but produce a clear, bright fire. When our seven boilers are going full blast not a particle of smoke can be seen issuing from the stack. The fire should be as near the front of the boiler as possible, and not half way back, as I have seen it with some burners, for with the latter you are losing a large part of the capacity of your boiler, while the former heats the water the full length of the boiler at the same cost. "Do you find it cheaper than coal?" is a question very familiar to me. Yes, we do find it cheaper than coal in Minneapolis, but whether it would be cheaper than coal anywhere I have my doubts, as it would depend altogether upon the cost and quality of the coal used. The best quality of Illinois lump coal costs us from $3.25 to $3.50 per ton, while eastern coals are worth from $4.50 to $5.50 per ton; I refer to bituminous coals. The oil costs at present 2½ cents a gallon delivered in Minneapolis. In comparing tests made by us with oil and coal, we find that 2½ barrels or 104 gallons, costing (at 2½ cents per gallon) $2.60, will evaporate as much water as one ton of coal that costs us $3.15, being a saving of about 21 per cent. in favor of the oil. With one pound of coal we evaporated 5.38 pounds of water; one ton of coal would, therefore, evaporate 10,760 pounds of water. With oil 14.8 pounds of water were evaporated per pound of oil. Oil weighs about seven pounds to the gallon; one gallon of oil would therefore evaporate 103.6 pounds of water. With oil at 2½ cents per gallon, it would take 126 gallons to cost the same as one ton of coal, viz., $3.15; 126 gallons of oil would evaporate 13.053 pounds of water, while one ton of coal evaporates 10.760 pounds of water, being a difference of 2.293 pounds in favor of the oil, or a saving of 21 per cent. When I consented to write this paper I fully expected to have tests made as to what we were actually doing now by indicating our engines, weighing the water and oil used, etc., but circumstances have been such as to make that impossible. I have, however, calculated from the number of lamps burning and motors running the amount of power we are using at present, and by doing the same thing when using coal I find that the percentage of increase in power used is considerably larger than the increase in cost of fuel, being about 15 per cent. Although I am fully aware that this way of figuring is not absolutely correct, still my figures thus obtained are so near the others mentioned that I feel they are not far out of the way, and that we are actually saving in fuel alone at least 15 per cent., if not 20.

My attention has been called several times to the fact that the amount of water evaporated by us, viz., 5.38 pounds per pound of coal was very low; that is true, but the quality of coal used was very low as well. I have made a few figures showing what would be required of coal at various prices to equal the cost of oil. With oil at 2½ cents per gallon, a ton of coal costing $3.50 must evaporate 7.25 pounds of water per pound of coal to equal cost of oil; or coal costing $4 per ton must evaporate 8.28 pounds of water, and a coal costing $5 would have to evaporate 10.36 pounds of water to cost no more than oil. Our experience has demonstrated that it takes a very good coal to evaporate 10 pounds of water per pound of coal, and that quality would be exceedingly cheap at $5 per ton with us.

Those of us who are interested in electric light plants know only too well how they are considered by insurance companies. We have had some difficulty in placing insurance, notwithstanding that all of the insurance men who have inspected our system are agreed that they cannot see wherein the danger lies, or that the risk is any greater than it was with coal. When we first introduced fuel oil our insurance rate was raised from 1¾ to 2¾ per cent. At that time our arrangements for handling the oil were about as crude as the oil itself, and although we thought the rate exorbitant, we submitted, trusting that, should we finally adopt the oil for fuel, the insurance companies would restore the rate to about the old figures; but no, it made no difference whether the arrangement was good or bad, the rate remained the same. Under certain conditions you are permitted to use oil without extra charge, but those conditions are almost prohibitory, especially if real estate is at all valuable in the vicinity of the plant. As, for instance, if you keep the oil in tanks 200 feet from your building above ground, or 100 feet if underground, it can be used without extra cost, I believe. Some companies allow the tanks to be as near as 50 feet if underground. I do not believe the danger lies entirely in the situation of the storage tanks—in fact, I think that has very little to do with it. There is no doubt in my mind but that the tanks should be underground and so arranged that they can be got at, and should a fire occur in the building and it become necessary to shut off the supply of oil, it could be done at the tanks as well as in the building. Our tanks are about 25 feet from the building, underground. I do not mean to say that no restrictions should be put upon the use of fuel oil; there should be, by all means; but where properly put in there is as little danger as from any other fuel used, and by properly, I not only mean the storage tanks, but the entire outfit, burners, piping, furnaces and all. I am of the opinion that the insurance companies will soon discover that they are making a great mistake in condemning the use of oil on general principles.

LIQUID FUEL.

BY M. J. FRANCISCO.

(Abstract.)

At the present time we have no knowledge of any means of securing light without heat, and it only remains for us to employ the most economical fuel to produce the heat without useless waste. It has been asserted that the question of dividends in electric lighting lies between the shovel and the dynamo, and the fraternity have been taxed to their utmost to provide a plan for dispensing with the shovel entirely, and thus securing at least a part of the much coveted dividend. Petroleum, it is claimed, will furnish the substitute. One pound of coal contains 12,000 heat units, while one pound of petroleum furnishes 20,000. Engineers who are familiar with the practical workings of coal know that under the most favorable conditions not more than 10 pounds of water can be vaporized per pound

of coal, while petroleum shows a vaporization of 18 pounds of water for every pound of oil, estimating in both experiments the feed water at 212 degrees Fahrenheit. But when we consider the waste, amounting in some cases to 25 per cent., found in nearly all coal, such as sulphur, slate and earthy substances which are incombustible and retard instead of generating heat, the difference is far greater than shown by the above comparison. There is also in coal a large percentage of loss in transportation, and combustion in the heap, varying from 5 to 10 per cent. From these facts we can safely conclude that the heating capacity of oil is nearly twice that of coal as generally used.

On this basis the only question to be considered is the cost of power furnished by each at the dynamo. Three and one-half barrels, or 955 pounds of oil, equal 2,240 pounds of pure coal, therefore with oil at $1 per barrel and coal $3.50 per ton, or oil at $1.50 per barrel, and coal $5.25, the difference in cost would not be so marked, if there were no other factors to be considered. When, however, we consider the saving in stoking, removing cinders and ashes, cleaning flues, besides securing a steady heat, quickness in starting and shutting down, we have an argument in favor of oil that stockholders who care for dividends can appreciate. I have found, upon investigation, that oil can be delivered at my station for $1.05 per barrel, while soft coal costs $4.50 and hard $6 per ton. On this basis, allowing five pounds of coal per horse-power hour, 12 hours per day, 1,000 h. p. requiring 803 tons per month at $4.50 would cost $3,613.50. Two firemen to feed the same, $100; man cleaning flues, etc., $45; carting ashes and cinders, $100; making total cost for 30 days, $3,858.50 with coal. The same horse-power for same length of time, allowing three and one-half barrels for each ton of coal, would require 2,810 barrels of oil at $1.05. This would equal $2,950.50. Wages of one man in boiler room, $50, making total cost of 1,000 h. p. one month, with oil, $3,000.50, showing a saving of $858 per month, besides getting with oil a steady flow of steam, and consequent regularity of speed. If you are now burning coal, it will be necessary to equip your station with tanks, burners, cylinders, oil pumps, compressors, air receivers and additional apparatus, varying according to the number and size of boilers used.

During the past few months the following facts have been gleaned from an extensive correspondence on this subject with parties who are using liquid fuel. The Boston & Albany Railroad Co., after a careful test made in their shops say that the cost of fuel is about the same. Though they purchase their coal in large quantities at low rates, they prefer liquid fuel, because it is clean and requires no fireman, and gives a better supply of steam. Day, Cordage & Co., of Boston, claim that with Cumberland coal at $4.50 per ton, and liquid fuel at $1.15 per barrel, they save 15 cents per 100 h. p. per hour. The Fairbanks Scale Co., of Vermont, report that they find oil a great saving over coal, while the boilers are heated evenly the entire length, also that the insurance companies have not increased their rates. T. P. Brown, manager of the Toledo, Columbus & Southern Railway, reports a saving of 33 per cent. of the price of coal, by using liquid fuel, also that two barrels of oil equal one ton of soft coal, while manufacturers on his road find it only costs one-half as much as coal for their stationary boilers. The rolling mill works of Chicago, use it under a battery of 14 boilers, and say that three and six-tenths barrels of oil does the work of one ton of coal. The cost of oil is less than coal, but the great saving is in labor for stoking, wheeling ashes and unloading coal. Formerly, when using coal, 25 men were required to operate this battery of boilers for 24 hours; now, with liquid fuel, four men suffice. The efficiency of the boilers is increased and cost of repairs lessened, while oil flame is less severe upon the boilers.

Reference could be made to hundreds of persons who have had practical experience in burning oil, fully sustaining the facts given above, proving conclusively that liquid fuel is at least one-third cheaper than coal.

It is, however, necessary to consider many points before deciding to adopt oil, especially if your plant is in the centre of a large city with other property in close proximity. Managers of insurance companies are just cranky enough to believe that oil will burn, and unreasonable enough to object to your exposing and destroying property for which they have to pay. Therefore, they insist upon certain conditions before they consent to its use. Among other things, that you store your oil 50 or 100 feet away from your station. If this should happen to place your oil tank adjacent to your neighbor's property, you will have the officers of the insurance companies operating in a way that will drive grounds, short circuits and underground wires out of your minds for a month. If necessary precautions are taken, and the apparatus is properly and securely arranged, there is no more danger with liquid fuel than with coal. In fact, it may be made safer, and insurance companies will permit its use without an extra charge. Examine carefully, however, from an insurance standpoint, any apparatus offered you, before attempting to use it, or you may find that insurance is an expensive luxury, and operates fully as disastrously upon dividends as coal.

An iron tank will be required for storage of oil, which should be located underground 100 feet from your station. A pipe from this must pass underground to the car for unloading the oil. A second iron tank, holding enough oil for one day's use only, can be placed immediately outside the boiler house, with a safety pipe one and one-half inches in diameter extending 10 feet into the air, to permit the escape of gas. This tank must be connected with the large tank by an underground pipe for forcing the oil into the smaller one, with another pipe for an overflow to carry the oil back or away, in case the pump is neglected or left running.

The small tank must be lower than the burners or furnace, so that in case of accident the oil will flow back to it. In all pipes there must be stop-cocks that will cut off communication between the burners and tank. The supply pipe at the boilers should be arranged with a valve not over one-half inch in diameter, so that oil cannot, under any circumstances, be forced under the boilers faster than it is consumed by the burners; thus preventing an overflow from flooding the fire box. There must also be an escape pipe extending outside the building for cleaning the tubes. In no case must the oil be allowed to flow from the tank to the burners by gravity, but must be supplied either by vacuum process, steam or compressed air. For this there are several plans: One is to force steam across the opening of a vertical pipe from the tank, and thus draw the oil up to the mouth of the furnace. Another is to use compressed air for atomizing the oil, and passing it to the burners. Others still use a retort and generate a gas. Unless the apparatus used is expressly arranged for starting the fire, oil must not be turned on until the burners are heated, for if it is, flashes and explosions will follow. If a station is furnished according to these conditions, the insurance companies will insure it without extra charge. If not, they will demand from 50 cents to $2 extra for every $100 insured, according to any deficiency that may exist, while if the burners are fed by gravity, it is a prohibited risk.

Faraday has stated that the chemical action of a grain of water upon four grains of zinc can evolve electricity equal in quantity to that of a powerful thunderstorm. The Springfield (Ohio) Electric Light Co. found by a practical experiment, made last December, that a small quantity of petroleum under certain conditions could evolve a sufficient amount of flame to annihilate an electric light station without any thunderstorm. They placed a storage tank, holding 160 barrels, in the basement of the main building, and another in the boiler house, containing the supply for daily use. From the last tank the oil was carried to the fires by gravity. Having received a fresh supply of oil, they filled the large tank under the building,

then turned the oil into the small tank in the boiler room, and left the pump working, while the men were busy in another part of the station. It overflowed the tank, and the oil escaped into the furnace, with the usual results from gravity pressure, less oil, less building and less lights, with insurance managers running wild over the hazard of electric light buildings.

It behooves the members of this association to investigate this subject, and correct the errors of the past, if they do not wish all electric light plants placed upon the prohibited list. For why should the most powerful and magnificent system for the protection of mankind, known as insurance, and the youngest child of science, electric light, appear as antagonists?

ADVANTAGES OF OIL AS FUEL.

BY C. N. RANSOM.

(Abstract.)

THE use of oil as fuel for the purpose of producing steam is still, in a certain sense, an experiment, and yet it is no longer a question of whether it shall be used, but merely a question of the manner and method to be adopted. The advantages are so obvious that it is hard to find a man who does not believe that some method will be found by which a steady, smokeless, economical and easily controlled flame can be produced from oil by means of which boilers can be heated in a much more satisfactory way than is now done with coal.

A large part of this feeling is due to the belief that oil can soon be obtained at about half the present prices. The Standard Oil Co., in combination with the Producers' Association, is struggling to maintain the price, but in order to do so they are holding back a reserve stock of millions of barrels, which they can at any moment throw upon the market, and merely postponing the inevitable result, cheap oil. Meanwhile the California oil wells are extending, and aside from the Pennsylvania and Ohio fields, others of large extent are discovered in Wyoming and other sections of the country, as well as in Canada. The export trade for oil is becoming less and is likely to cease entirely, on account of the refineries erected by the Nobel Bros. in Baku, Russia. Quite recently Nobel Bros. have erected extensive refineries, and are understood to be constructing pipe lines, which must result in cutting off all our export trade in oil to Europe.

The heat-producing value of petroleum, compared with pure carbon, is as 28 to 15; and, compared with a fine quality of coal, as 28 to 14, or 2 to 1; and 1,000 pounds of petroleum are equal to a ton of coal. As petroleum weighs 6½ pounds to the gallon, 154 gallons are equal in heat-producing power to a ton of the present coal. In practice, however, the heat producing power of coal, as used under boilers, is very much less than the possible production stated. Referring to Professor Tower's work, we find that in actual careful tests of over 40 different articles of coal the highest evaporation reached was 10.7, and the other results varied from 6 upward, showing a loss from the estimated possible result of from 30 per cent. to 60 per cent. We have been unable to learn of a single instance in which a higher evaporation than 10.7 has been reached with coal, and have learned of only a few special tests in which an evaporation of over 9 has been reached. Such results have been reached only with exceptionally good boilers, with feed water heaters and the best of modern appliances to utilize all the heat, avoid radiation, etc., and with the best of coal and the most careful handling. In regular use, however, even in improved horizontal tubular boilers, with all improvements, the usual evaporation is from 7½ to 8½ pounds of water per pound of coal used, and in ordinary vertical tubular boilers the evaporation rarely exceeds 6 pounds of water to the pound of coal, and is oftener less than more. All these facts must be taken into account in considering the question of the possible value of petroleum as a fuel. Coal has been the universal fuel, and steam boilers are specially adapted and built for its use. Devices for producing perfect combustion of coal, and for utilizing the heat derived from it, have been patented by the thousand, and constant familiarity with its use in manifold ways has produced about as good a result with coal as we can well hope to reach, and this result summed up is that whereas one pound of coal can be made in laboratory practice to evaporate 14 pounds of water, yet in common use, in good horizontal boilers, the average evaporation is but 8, showing a loss of 43 per cent., and in common use, in upright tubular boilers, the average evaporation is only 6, showing a loss of 60 per cent.

Reverting to our former figures, it is evident that if 1 pound of oil is equal to 2 pounds of coal—under laboratory tests, where 1 pound of coal evaporates 15 pounds of water, and 154 gallons of oil equal 1 ton of coal—then when there is a loss of 43 per cent. on the heat-producing power of coal, as in horizontal tubular boilers, 88 gallons of oil (if there was no loss in using it) are equal to 1 ton of coal.

It is evident that if such results as these could be accomplished, and other objections overcome, oil would be in universal use.

Whether such results can be reached or not is difficult to predict. Inventions in the line of apparatus for burning oil to produce steam are comparatively recent. Nearly all of the inventions are in the line of atomizing or injector burners, and there are probably few, if any, horizontal tubular boilers in which oil is used as a fuel with any but an atomizer or injector. Burners of that description and of several forms have been in use for several years.

The Cincinnati Spring Co. wrote last June that they had probably used upward of 10,000 barrels of crude petroleum with atomizing burners, and preferred it to coal; and that they had tried all kinds of injector burners, but make one out of their own that suits them better. The Michigan Bolt and Nut Works, of Detroit, wrote on May 14th: "We tried the 'Askins,' the 'Chicago Edwards' and a simply constructed burner of our own, using gas pipe, and we liked ours as well as any." Studebaker Bros., manufacturers, of South Bend, Ind., wrote on May 14th: "We have not yet determined what make of burners is the best. We have had about as good results with one we made in our own shops as with any." Of this class of burners there are any variety in use, with more or less success. In my brick-making and certain classes of furnaces they seem to be regarded as being very satisfactory.

There have been, however, some serious objection to their use in boilers. In the first place, it is always necessary to make a fire in some other way first, in order to produce a sufficient pressure of steam to start the burners; and it seems generally the case that they will not work on less than a 30-pound pressure. One of the consequences is that if the steam happens to run down it can only be raised again by shutting off the oil and making a fire of coal and wood. They are, therefore, of no use, except where a long-continued high pressure and a constant fire are maintained. Another difficulty with that class of burners is that their practical use seems to be limited to horizontal tubular boilers, were the flame can be allowed to shoot through a long distance without coming in contact with the iron, the flame being thrown generally upon or against fire brick.

Messrs. Keasley & Mattison, the celebrated chemists of Ambler, Pa., say: "The furnace must be lined with fire brick, and satisfactory results can then only be obtained after the fire brick reaches a white heat. The fact seems to be that in the atomizing process the oil is sprayed in small globules, and if these globules strike a cool surface or one not excessively hot before they are entirely consumed, the result is imperfect combustion and a large amount of smoke." This peculiarity of injector burners seems to render their use impossible in locomotives or vertical tubular boilers. In fact, I have seen letters from at

least 70 different leading firms and well-known companies, located in almost every part of this country, stating in almost every instance that, while they knew of injector burners, etc., they never knew or heard of an apparatus for burning oil under boilers which did not require the use of steam or compressed air; nor did they know, nor had they heard, of any apparatus whatever for burning oil used successfully under vertical tubular boilers. I have also seen a letter from the manager of the fuel oil department of the Standard Oil Co., stating that he knew of only one burner which could be used under vertical tubular boilers. It is also a fact, I believe, that no burner has yet been brought into general use under house-heating furnaces. I believe it is now generally conceded that the use of atomizing or injector burners cannot be extended to embrace either vertical tubular boilers or boilers of the locomotive or portable type, or even horizontal tubulars below 50 h. p. In fact, the system of atomizing does not appear scientific. It seems upon its face a crude and clumsy way of producing combustion. I believe, however, that the members of this association recognize few impossibilities, and are convinced that a device can be made by which oil can be burned, and which can be easily and perhaps automatically controlled; and it would seem that such an apparatus would go a long way toward solving the problem of isolated lighting. For such a device we must, I think, turn to the system of converting the oil into gas first, and then burning it. Such a system is in accord with the principles of science. Of this class of devices the greater number have consisted of coils of pipe, maintained at a high heat, in which the oil is vaporized, and from which the vapor or gas issues in jets and is burned. These coils of pipe, however, I think, without exception, have proved failures, because of the coking or accumulation of sediment. Attempts have also been made to burn oil and water together, which have so far proved unsuccessful, chiefly because of the great difficulty in adjustment, and because they have been too complicated. Another defect has been that the vapor issuing from the tubes produced a smoky flame of comparatively small heating power. Still another difficulty has existed in the fact that if, by carelessness, the valves were opened too far, the oil would overflow.

Some time since my attention was called to an oil burner of the vaporizing type, which was submitted to several eminent scientists and to a number of practical men, and was approved by them. In that burner the oil was first turned into gas, and then gas, issuing in small jets, was mixed with air before combustion, upon the general principle of the Bunsen burner. The result produced was a steady, entirely smokeless flame. The cylinder was large and capable of producing more gas from the oil than could be discharged under light pressure through the jet holes, and the tank was elevated so as to give a gravity pressure of about four or five pounds to the square inch. The result was that the gas stood in the cylinder at an even pressure exactly equal to the gravity pressure maintaining the steadiness of the flame, and no oil would flow into the generator except as the pressure was lessened by the consumption of the gas, even when the fuel valve was opened wide.

Whether that particular device was or is the best or not, it seems to me that some device constructed upon that line must produce the best results obtainable, viz., the oil should be turned into gas and the gas burned after admixture with air, upon the same principle as ordinary gas is burned in stoves. Some of the advantages which a successful apparatus for burning oil would have are easily understood, and are: steady flame, perfect control, slight draft required, the power to increase or decrease the flame at will by the simple turning of a valve, the power to maintain steam at a steady pressure, the slight attention required, the power to extinguish the fire instantly without waste, the uniform heat, no reduction of fire or pressure when replenishing the fire, cleanliness, safety, economy in labor, no dust, cinders or ashes, less room required to store the fuel, and only one-third the weight.

With these advantages to be derived from the use of oil as fuel, it seems only reasonable to expect that within the near future some successful apparatus will be brought into general use for manufacturing and house-heating purposes.

CONDUITS; THEIR MATERIAL IN RELATION TO INSULATED CONDUCTORS.

BY ALEXANDER C. CHENOWETH.

(Abstract.)

Many miles of structures of various kinds with insulated conductors in them, are now to be seen in New York, Brooklyn, Philadelphia and other cities. While the conduits do not present any very important signs of decay, the insulation of the conductors has given evidence of decomposition in various stages, in some cases giving out entirely. Those covered with rubber compounds have given place to others, with some protected by a lead covering. Very little attention has been given to the subject of electro-chemistry; failure being attributed to various causes, remedies suggested by mere circumstance have been resorted to. That electro-dynamic forces have contributed to the trouble can hardly be denied. Creosoted wood ducts and iron tubes are the prevailing forms. Illuminating gas and moisture were found in most of them. Rubber insulation was rapidly destroyed, and lead-covered cables were corroded to such an extent in creosoted wood ducts that other cables covered with an alloy of tin and lead were substituted, and even with these it was found necessary to coat with paint. In the iron tubes corrosion was much slower.

After a careful examination of conduits and conductors, I am led to believe that decomposition of insulation and covering is due to electro-chemical action. The existence of a natural voltaic action in the earth, is without doubt true. But the establishment of the principle that a certain electrolytic intensity is necessary before decomposition can be effected, is of importance in considering the probable effect of the earth currents. For to produce an effect of decomposition or of combination a current must have a certain intensity before it can overcome the quiescent affinities opposed to it, otherwise it will be conducted, producing no permanent chemical effect.

Electro-chemical decomposition is produced by a force either superadded to, or giving direction to, the ordinary chemical affinity of the bodies present. In this view the effect is considered essentially dependent upon mutual chemical affinity of the particles of opposite kinds. Bodies dependent on weak affinities very rarely give way. Take for instance glasses, those formed by silica and an alkali. It is evident that in all cases in which decomposition does not occur it may depend upon the want of conduction; this being true, good conductors, such as iron, should never be selected for conduits.

I call your attention to a piece of cable taken from a creosoted wooden conduit in Brooklyn. The lead covering was eaten full of holes. It has been down over a year. Creosote was attributed as the cause of decomposition. Illuminating gas and moisture were present in the ducts. It was reported a rubber compound insulation was destroyed in the same duct. Examination was made of iron conduits with lead-covered cables in them, and decomposition was plainly seen in various stages, although the lead covering was not so rapidly decomposed as it was in a creosoted wood duct. Moisture and illuminating gas were present. The deposit on surface of lead proved to be carbonate of lead.

In pursuing this examination I found a peculiar case deserving consideration, I found exposed to view in a man-hole a cable that was covered with an alloy of tin and

lead. This cable had been down about four months; it passed through the man-hole into the duct; the part exposed to view was about seven feet; the duct was constructed of iron and cement. On one side considerable decomposition appeared, being very active for about two feet of the exposed part, which rested on the bottom of the man-hole. A large iron pipe for water traversed the man-hole parallel to the cable. The crystals of decomposed lead extended toward the iron pipe, being quite profuse, adhering to the brick and side of man-hole. On examination the white crystals proved to be carbonate of lead. Moisture was present, but no illuminating gas. I placed a piece of lead on the cable at this point. After two months I removed it and found the same covered with crystals of carbonate of lead, showing signs of electrolytic action between the lead-covered cables and iron pipe, moisture acting as the exciting liquid.

I found in Brooklyn a cable that was conducted into a building some distance from a creosoted wood duct; this cable was also decomposing in spots, while no odor of creosote or illuminating gas could be detected. The moisture may be the exciting agent, accelerated by creosote and illuminating gas. This action may be explained by the reaction of the constituents of each portion of decomposable matter, affected as they are by the supervention of the electrical currents; portions of the proximate or ultimate elements proceed in the direction of the current as far as they find matter of a contrary kind capable of effecting their transfer, and being equally affected by them; and when they cease to find such matter they are evolved in a free state upon the surface of metals or air bounding the extent of decomposable matter in the direction of the current. Hydraulic engineers frequently find an electrolytic action set up in stopcock valves underground when they are made of two kinds of metals. Examination has shown that water impregnated with iron or saline matter has produced this action. I was informed by a very eminent engineer, who is now chief of the Croton aqueduct in New York city, that metals of different kinds underground invariably present marked evidences of decomposition when in contact. Faraday has shown that these electrolytic actions do not depend on contact alone.

In order to avoid any electro-chemical action, iron tubes, creosoted wood ducts, or any material that can become the means of establishing this action should be discarded.

A triple silicate of lime, magnesia and alumina, artificial stone, form a substance more neutral than any other. The selection of this material for underground structures in form of concrete was probably the result of long experience rather than the knowledge of its physical relations, as presented by electro-chemistry.

Attempts to counteract the electro-chemical action on a lead covered cable by placing another substance in juxtaposition has not proved a preventive; it may delay it; this is also true of alloying tin with lead. Metals may combine when melted together, but they do not remain combined after the solidification of the mass. I present here an example. I refer to a piece of brass tube that was used for pneumatic transmission by the Western Union company in New York, being buried in a wooden box in one of the streets. After it had been down some time it was so eaten full of holes that it required renewing. Upon examination you will find the zinc is eaten out, while the copper remains; the action was on the outside, while inside the brass remained perfect; air traversed the inside continually, while moisture and other agents produced an electro-chemical action, thus showing the peculiar effect of the earth currents in decomposing the zinc in this alloy, then removing it entirely. Moisture and gases must be removed by ventilation. In order to accomplish this the diameter of the conduits should be not less than four inches, and some relative proportion be established between the diameter of the cable and diameter of the duct, otherwise the power required to force air through would be beyond an economic limit.

The subject of ventilation for electrical conduits not only becomes important in order to protect the conductors in them, but in order to protect life and property. Thursday, December 20, 1888, an Edison man-hole exploded in Maiden Lane, New York city. January 19, one month later, an explosion took place in Nassau street. In November, an Edison man-hole exploded in Boston. These explosions have been attributed to accumulation of gas.

MUNICIPAL LIGHTING.

BY FRED. H. WHIPPLE.

(Abstract.)

"MUNICIPAL LIGHTING," as generally considered, means the municipal ownership of the plant. I think this definition is erroneous, for the reason that the greater portion of the income of two-thirds of the electric light companies of the country is derived from their public street lighting contracts. Of the total number of arc lights manufactured by private companies who are parties to a city contract, 68 per cent. are public lights, and are paid for by the municipalities. On the other hand, of the total number of arc lights upon the streets of the land, but one-third of one per cent. are owned and operated by municipalities. Therefore the subject is not confined entirely to the question of ownership. The issue, to my mind, is based as much upon the rental value of an arc lamp.

What is the rental value of an arc lamp? Statistics regarding the price paid by various cities are not lacking; but comparisons are worse than useless, for they seemingly go upon the principle that a light is a light, no matter what it lights, what it costs to produce it, whether it has good illuminating capacity, or whether the system be an inferior or superior one. The prices for light vary materially in different places, but I have been unable to see that they vary in accordance with any fixed relation to any other factors. It would be impossible to prove, on a general hypothesis, that 50 cents, or any other sum, is in any place the exact value of an arc light; but in this, as in all other cases, some price must be fixed.

In staple articles the law of supply and demand regulate prices; but as electric light companies, in their relations to city councils, act under influences individual in themselves, the case is different. The price of light for commercial purposes is to some extent regulated by the fact that moderate prices materially increase the consumption, but in municipal lighting, the city, if it accepts the terms offered, generally pays the contracted price. It is, therefore, in many if not in most cases, a matter of comparative shrewdness on either side as to the price paid, and the service rendered.

There are to-day in the United States 316 cities and towns whose streets are wholly or in part illuminated by electric lights furnished under a public contract. The highest price paid for an arc light of nominal 2,000 candle power, burning all night, is $360. The lowest is $40. Between these two extremes there are 186 prices. Upon the moonlight schedule the maximum figure is $165; the minimum $50.

What makes these wide differences in price? Granted that in many places local conditions, excessive competition or the absence of all competition have weight, what reason shall we give for the varying figures exhibited in a wide field of localities where the conditions are almost identical?

The average cost of all-night public lighting in the United States to-day is $121 per light; for schedule lighting, $110. In 1885 the cost was, on an average, $167 per light for all-night lighting, and $135 for schedule lighting. In 1886 it was $160 and $125. In 1887 it was $130 and $117. In 1888 it was $129 and $114. Thus we find that

the price of public lighting has been steadily decreasing for several years, and to a large extent within the past few months. Contracts that have been renewed since the last meeting of this association in August show a net reduction upon all-night lighting of 23 per cent., and upon schedule lighting of 19 per cent. The general run has been from 15 to 33 per cent., but there are several cases reported where the reduction has exceeded 50 per cent. An increased contract price is rare.

These statistics do not furnish any guide as to the rental value of an arc lamp. The price paid by one city is often twice as much as that paid in a neighboring city. It is obviously worth more to produce a light in one place than in another, but is it worth twice as much? It will no doubt be said that different degrees of illuminating power enter into the problem, but in my computations I have considered none but nominal 2,000 candle power lights. Sometimes the area lighted is pushed forward in explanation, but this has no connection that I can see with the cost of the light itself.

There is really no fixed basis upon which to charge for public lighting, nor any general data by which a fair rate may be arrived at. I am, therefore, of the opinion that coincident with the discussion of ownership should come that relating to the value of the light, for this is really the primal cause for so much agitation of municipal control.

When it comes to the question of ownership there are three parties in interest: the parent companies who manufacture the material to be used, the local companies that have invested their capital in a business they have the right to make lucrative, and the public, represented by municipal councils. Accordingly, we find three separate views taken of the question, and are forced to believe that all three are right from their standpoint.

Of the three factors the local companies are the only ones presenting a solid front. They are united in the opinion that municipalities ought not to do their own lighting. In view of the constant decrease in the price of electric lighting, and the transitory periods of electrical machinery, the local companies are correct in their claim to be able to generate electricity as cheaply as a municipality. Many of the circumstances by reason of which the sentiment favorable to municipal ownership became prominent do not have force to-day. The improved methods and cheapening processes private companies are able to take advantage of where municipalities would not. Compound and condensing engines have made it possible to reduce the cost of power; light is produced from a less expenditure of energy; carbons have fallen from $50 and $60 to $8 and $10; it is no longer necessary to locate a station in the central, and therefore most expensive portion of a city, and more attention is given to water power. All those are contributary to the claim of the private companies that municipalities should not enter into an investment the extent of which they are ignorant of in the face of a declining market.

With the parent companies the effects of municipal ownership are just beginning to be appreciated. There is no doubt but these organizations will at no distant day be brought squarely to face the alternative of refusing to sell material to municipalities altogether, or of going out of business. It has been their custom, while acknowledging an unwritten obligation to protect their local companies, to consider that they are not bound to refuse a sale. They are not prepared to say that it is inadvisable for a city to operate its own plant so long as the city already has the other company's system installed. When it comes to a city which has a private plant of this or that particular system, then this or that particular parent company is decidedly opposed to the city embarking in the business.

No parent company is large enough or financially strong enough to organize and operate the local companies necessary for the times. Therefore it is local capital that is the mainstay of the parent companies. Capital is always nervous, and we can readily see that with the continued growth of a sentiment favorable to cities doing their own lighting, capital will not run any risks. It will not invest in a city or town where a community interest stares it in the face.

I do not believe there is a parent company in the country that has made money by selling plants to municipalities; I know some who have lost money, and I wonder that as a whole they are not ready to commit themselves unqualifiedly and negatively upon the subject of municipal ownership. The time is near when they will be forced to go upon record in this matter, but to-day they are vacillating and uncertain.

The theory of some political economists is that the monopolies of service should be owned by the municipality, and all belong to the community. In European countries this idea is carried to a much farther extent than in our own. In America this doctrine has made less progress, and considering the character of our political methods that is well. Municipal service can be, and ought to be, quite as free from corruption as when in private hands. But in few instances do we find it so. I believe I can truthfully say that the experience of city governments in electric lighting has not been in all respects satisfactory. Starting out a year ago as the investigator for a large municipality, I have closely studied the working of almost every city plant, and with but one or two exceptions I would not commend their operation. The officials of the smaller towns where municipal plants have been installed, with an amount of crude ignorance of the subject that is truly appalling, do not hesitate to assert that they and the people are well satisfied with the experiment; but in the majority of cases these officials are in office through the machinations of rings.

On one occasion, where I was called upon to estimate the cost of all-night service for a large city, upon its merits, my figures were $92 per year, with interest and depreciation, and that I think is not very far from the cost of an arc lamp in our average communities. A strong claim is made that municipal stations have reduced the cost of public lighting in their localities over the contract system.

I have previously stated that the average present price of public lighting in the United States is $121 per arc lamp per year, burning all night, and $110 per lamp burning on schedule. The average cost to municipalities which are furnishing their own light is $76 for an all-night light, and $44 for what they term a schedule light. This schedule is deceptive, and does not provide for as many hours' lighting as the usual contract does. Therefore, the latter suffers by comparison. It is often the case, also, that the light is furnished in connection with some other department which bears a portion of the interest and depreciation account. Free water power and sometimes so-called free attendance also enter into these figures and distort them.

The only argument worthy of consideration in favor of municipalities doing their own lighting is that of cheapness, and emphasizes what I have said, in a previous part of this paper, that an important question involved is the rental value of an arc lamp. Municipalities have not yet succeeded in reducing the price of light abnormally below the average. I do not consider the fact of any weight that a city, by reason of its not being compelled to pay taxes, and because it has no profit to make can manufacture light cheaper than a private company, for I expect that what it saves in this way will be counterbalanced by losses caused by the influences of its management.

Here arises the question of a personal financial responsibility. We have become accustomed to consider that all public business, being in a sense everybody's, is really nobody's, and too often it is the case that a mere perfunctory public duty is performed for the sole sake of the salary attached to the office. Any business enterprise, to be con-

ducted successfully ought to be carried on by men who are financially interested in it, and who feel in their own pockets the cost of every expenditure. A city government cannot possibly take that view of it, even though its departments were paved with good intentions.

The price of public lighting has outstripped all other questions in the financial management of our cities. It has become, if not the chief source of expense, the greatest bone of contention, and the electric light companies that will observe the handwriting on the wall and meet the subject half way will do much to dissipate the sentiment antagonistic to its interests.

MUNICIPAL OWNERSHIP OF COMMERCIAL MONOPOLIES.

BY A. R. FOOTE.

(Abstract).

The true name of this subject, designating accurately the economic principle which it advocates, is Municipal Slavery—a scheme to enslave capital and pauperize the people. The economic principle advocated is not in accord with natural economic law; therefore, it is an obstruction to the progress of civilization.

Those here assembled know that all progress is due, and must ever be due, to the discoveries of science made available for the uses of man. The nearer we arrive to an understanding of natural law, the nearer we apprehend the truth. Actions guided by truth are the guarantors of benefactions. You who have experimented, with great patience and at great cost, to discover the natural laws governing the generation and control of electric energy, know how impotent all your devices are to compel that energy to serve you, if they fail to comply with the conditions of those laws. The same fact is true in economic science. If economic policies do not comply with natural economic laws, the effort is impotent to secure the best economic results.

Public ownership of commercial monopolies is advocated upon the supposition that, if worked without a profit, the economic result will be a benefit to the people. Work without profit is slavery. Slavery is not an economic benefit.

That capital is entitled to a profit for its use and risk is the foundation law of all economic science. There is not a recorded instance in the history of finance where an interference with the operation of this law has secured a permanent benefit for the people. All evidence shows that, where this law is allowed to operate with the greatest certainty, there capital is most abundant, works on the smallest margin, and produces the most healthful progress.

Capital is the conserved energy of individual action ; it never loses its individual character.

When the attempt was made to christianize communities by government authority, they remained heathen. When communities attempt to become rich by operating commercial monopolies without a profit, they will be made paupers.

A man's capital is his power to produce. Surplus is the product of energy in excess of the wants of life. Capital is the conserved energy of surplus. Surplus is an individual creation, and belongs by natural right to its creator. To abrogate the law of increase for use and risk is to destroy the only economic inducement men have to create a surplus. Deny men the ownership of their surplus, and they are forever slaves. Deny men an increase for the use and risk of their surplus, and the forces of progress will be paralyzed.

The application of these generalizations to the question before us is easy.

First. There is no municipal surplus, unless it is taken from the surplus of individuals by taxation. This makes the individual poorer.

Second. Working public monopolies for a profit is securing income by indirect taxation. Indirect taxation is a tax on consumption.

Third. When public monopolies are not worked for a profit, their products are sold at a reduced price. This compels all private capital to abandon the business undertaken by public monopoly. By this process all the forces of progress for that industry are paralyzed.

Fourth. Every industry grows as long as it produces, or gives promise of producing, a profit for the use and risk of the surplus invested in it. When, for any reason, the hope of profit fails, the industry dies. Expectation of profit is the life of industry. Its growth is the ratio to the per cent. of profit promised, plus the certainity of securing it. In the beginning, surplus created in some older industry is transferred to a new undertaking to give it life. If the new undertaking fails to create a profit, it loses its power to draw life from other industries and dies. It has failed to demonstrate its right to exist. For this reason, that man who so orders the conditions under which an industry must be worked as to deprive it of the power to create a profit is its murderer.

I know of no industry which has been developed to the best of which it is capable under public ownership. This subject may be illustrated by reviewing the development of the gas lighting industry.. Sixty-eight years ago, the first plant in the United States was installed in the city of Baltimore. To-day there are about 1,000 plants in operation, which have cost about $500,000,000. If this industry had been worked under conditions depriving it of the power to create a profit, could this enormous capital have been collected by taxation? If not, by what means would the cities of this country have obtained the benefits of gas lighting? This is not all. The power to create a profit, and the right to own the profit created, has proven a powerful stimulant to invention and improvement. By these processes, service has been improved and cost reduced, until the present price is but a fraction of the original charge. In 1878, the average price of gas in 290 cities was $3.15. In 1887, the average price for the same cities was $2, a decrease of 33 per cent. in nine years. The process is still going on. The decrease in 1888 was in a greater ratio than the average for the preceding nine years.

Four gas plants are owned by municipalities—Philadelphia, Pa.; Richmond, Va.; Wheeling, W. Va., and Danville, Va. Not one of the inventions or improvements that have benefited service or cheapened cost have emanated from either of these plants. Neither of the older works are in line with the improvements of to-day. Richmond is now engaged in improving its plant. When the work is finished, as ordered, it will be in line with the improvements of ten years ago. One special point avoided in making changes is the reduction of the number of employés. Is there any political significance in this? Philadelphia has just contracted with private capital to furnish 3,000,000 feet of gas per day to the city gas works. Why? Because the city cannot make it for itself, as its works are not supplied with the necessary improvements.

Here is a comparison of the price of gas in six cities :—

	1873.	1888.	Per cent. of decrease.
New York	$2.75	$1.25	54½
Philadelphia	2.30	1.50	35
Baltimore	2.75	1.00	63½
Richmond	3.00	1.50	50
Cincinnati	2.25	1.15	49
Cleveland	2.50	1.00	60

But why give data and make comparisons that have no scientific value, because all the factors influencing the result are not considered? If public ownership is not founded on correct economic principles, then the result of such ownership cannot produce the best economic results.

Let us now consider the effect of public ownership on our own industry. It is acknowledged that no city has yet undertaken to supply its citizens with a complete electric

service. If the industry is to be developed by public ownership, why do not these cities commence in line with the progress that has been made? If they have not the enterprise, can there be a reasonable hope that they will ever catch up, keep up, or contribute to the forward momentum? To-day, private capital is ready to install electric central stations having proper apparatus and sufficient capacity to perform the entire electric service of a city.

This service now includes:—Arc and incandescent lamps for street lighting; arc and incandescent lamps for commercial lighting; incandescent lamps by meter measurement for domestic lighting; stationary motor service for all mechanical uses; motor power for operating street cars.

One of the largest companies manufacturing electrical apparatus has installed electric central stations in about 160 cities. The combined capacity of these stations would fall far short of performing the entire electric service for the city of Chicago, if the service in that city was developed to the best of which it is capable. Can anyone calculate the difference in cost of installation, operation and administration between one station, combining the capacity of the whole, and that of the 160 stations located in as many different cities? To-day, electricity is at its highest cost, and gas at its lowest cost. Gas has fifty years the start.

To supply a complete electric service to the cities of this country, in a manner now known to be practical and best, will require the investment of over $1,000,000,000. Do the manufacturers of electric apparatus expect this vast sum to be raised by successive tax levies? If not, then they must secure its accumulation through private ownership, operating electric central stations for a profit. There can be no hope that the electric industry can reach the highest degree of prosperity of which it is capable, if it is sold into slavery in its youth.

Fortunately for us, our industry is not the only one needing defense against the promulgation of communistic theories. Those who advocate such theories are consistent enough to push them far toward their logical conclusion. It is well that they do so, for it is the most helpful service they can render those who would resist the encroachments of their economic policy.

Doctor Richard T. Ely, associate professor of political economy in Johns Hopkins University, may be recognized as chief in the school of communistic philosophy. By reading his books it is easy to see how, as he familiarized himself with the idea of public ownership, the list of so-called "natural monopolies" expanded, until by it he furnishes a logical reason why all industries should be so owned and operated, if any one of them should. A mere mention of the monopolies he recommends cities to buy will give a good idea of the progress he has made in communism. They are as follows:—Gas supply, street car service, highways and streets, electric lighting, all railways, canals, bridges, lighthouses, ferries, docks, harbors, natural navigations, postal service, telegraphs, telephones, abattoirs or slaughter-houses, markets, union depots, express business. This list illogically associates non-commercial with commercial undertakings. In it are embraced a large percentage of the industries of the country. If it is so desirable for the public to own so many, why specify? Why not own all industries? It would be interesting to know what additions would be made to public investment, public income, public patronage, and to the number of public employés, if the recommendations of this economist were acted upon, and this entire list of undertakings were transferred to public ownership. Could the party then in power ever be voted out?

This list is serviceable in another way. It shows the interests that should unite with us in combating communism.

In his address before the Boston Merchants' Association, at its annual banquet, January 8, 1889, Professor Ely said:—"I say, then, that cities should pursue a policy looking to the ultimate ownership and management of all local monopolies. * * * This is most intimately connected with local taxation. One of two methods may be pursued.

"*First.* These monopolies may be worked for a profit, and by profit taxes may be reduced; or,

"*Second* Charges may be reduced, and increased general prosperity will furnish a more plentiful source of taxes, and thus allow a reduction of the rate."

Profit on the products of public monopolies is taxation on consumption. Taxation on consumption is indirect taxation.

Since Professor Ely recommends that gas lighting, electric lighting, street car service, and numerous other industries be owned by the public, and then operated for a profit to reduce taxation, it will be well to learn his views on indirect taxation. Here they are:—

"Indirect taxes violate the principles of equity, * * * we import salt and tax it 50 per cent. of its value. Does the rich man consume more salt than the poor man? * * * We have in a tax like this what is called a regressive tax, a tax which increases as income decreases—*the worst kind of a tax, and the most unjust.* * * * Indirect taxation does not discriminate between the last dollar of the poor widow and the dollar which is only one in an income of a million. It raises prices, reduces the value of income, and forces some who are already near the awful line of pauperism to cross it, and thus puts to death higher aspirations in a class of citizens, and lowers the level of civilization. * * * Indirect taxes are imposed upon people without creating so much discontent as direct taxes, and without occasioning so close a scrutiny of the methods in which the proceeds of taxation are expended, because the mass of men do not realize that they pay taxes every time they purchase dry goods or groceries. Indirect taxes are an underhanded kind of taxation. It is not, then, surprising that they are, in the minds of many, identified with despotism and aristocracy, while there is a growing opposition to them on the part of enlightened democracy."[1]

Is it not surprising, that an economist who sees the character of indirect taxation so clearly should recommend those who are so oppressed to extend the list of oppressors from dry goods and groceries to gas lighting, electric lighting, car fares and a long list of other things? Are the rich so poor that it is necessary that one penny out of every car fare paid by the poor should go to help reduce their taxes, or are they mean enough to want it done? Suppose that all these industries were owned by the public, and the profits on them were sufficient to pay *all* the taxes, would not the payment of the tax be in inverse ratio to the income of those who pay it? Can any form of tax be more inequitable, more unjust? The short of the first proposal is, then to tax the poor and relieve the rich.

That which has been said about the slavery of capital is a sufficient answer to the second proposal.

He who assumes to be a scientist and a teacher should be accurate. Professor Ely is reported to have said, without explanation, in his Boston address: "Gas can be made and sold at a profit for 37 cents. I say it can be done, because it is done in the city of Philadelphia; parties supplying the city with gas at that figure." What do you understand by that? Does it not convey to you the idea that the consumers of gas in Philadelphia are being supplied at 37 cents? Well, the truth is, that the gas works are owned by the city. On account of a lack of the latest improvements, the city has contracted with *private capital* to supply 3,000,000 feet of gas per day. This is a carbonated water gas of high candle power, and is mixed with the city coal gas to increase the output and improve the quality of the gas manufactured by the city works. The

1. See Taxation in American States and Cities.

consumer of gas in Philadelphia pays $1.50 for his gas as before. This is held as a sample of the benefits of public ownership. This from a teacher of economic science!

Professor Ely presses his point still further, by saying: "It was the best citizens of Philadelphia who insisted that the gas works should remain city property when the gas trust expired." What scientific or economic value has a reason like that? It is the argument of a politician, from the fact that he is teaching that a tax of one penny in every street car fare "would relieve to that extent the business men of cities from their load of taxation," it is fair to presume that by "best citizens," he means the respectable wealthy people. *They know* that the $3,000,000 which they found in their budget of 1887, as receipts from gas (Taxation in American States and Cities, page 271a), came by indirect taxation from the people who consumed most gas—the majority—who are poor. This is the reason why THEY insisted that the gas works should remain city property.

One of our "best citizens" is seeking to ease the burden of taxation for the rich, by collecting pennies from the poor, under cover of charges for gas lighting, electric lighting, street car fares and other products of industry. He advocates an economic theory which must result in the slavery of capital and the pauperization of the people.

ABSTRACTS AND EXTRACTS.

A DESIGN FOR A STANDARD OF ELECTRICAL RESISTANCE.[1]

BY J. A. FLEMING, M. A., D. SC.

(Professor of Electrical Technology in University College, London.)

In designing a standard of electrical resistance the two points to which attention is directed are the choice of the material in which the standard is embodied, and the form or disposition of the instrument.

Experience is yet far from complete as to the entire permanence of wires of alloys over prolonged periods of time when employed as standards of electrical resistance; but having regard to the inconveniences which attend the use of mercury in standards intended to be conveyed about, evidence, as far as we have it, points to the tolerable permanence of the platinum silver alloy (66 p. c. of silver + 32 p. c. of platinum) when drawn into wire, for use as the material substance of which the actual standard is made.

A definite length and gauge of standard wire has then to be so arranged that, whilst kept at a constant temperature, currents can be passed through it and the resistance between certain points ascertained.

The form which has hitherto been chiefly manufactured, and which is in most general use, is the form of standard which was designed by the committee of the British Association on the original introduction of the B. A. unit. In this form of standard the actual coil is wound on a bobbin, consisting of a tube of thin brass having ebonite cheeks. Attached to these cheeks are the two long bent copper rods which serve as the electrodes, held in position by a distance piece of ebonite. In order that the coil may be immersed in a medium of known temperature it is further enclosed in a thin shell of brass consisting of a double tube, and the whole shell filled up with paraffine wax or ozokerit. Some makers then place a thin lid of ebonite on the top of the shell.

Experience gained by a rather extensive use of standards of resistance of this form has indicated to the writer that this design can be, with some advantage, modified. The disadvantages of the present B. A. form of standard are as follows:—When in use the standards must be placed in water of a known temperature or in melting snow or ice. After a sufficiently prolonged time the temperature of this water can be taken, and the temperature of the water will be the temperature of the wire of the standard, assuming that equilibrium of temperature has been attained. If a current is now passed through the coil in order to take a measurement of its electrical resistance, the temperature of the wire is raised, and its resistance is altered.

Other things being equal, the best design of coil is that in which this electrically developed heat is got rid of by diffusion as quickly as possible. The embedding of a coil in a large mass of badly-conducting material like paraffine or ozokerit is, from this point of view, a great disadvantage.

Sufficient electrical insulation has to be provided; but this should be achieved without the use of more enveloping insulation than necessary.

The two chief objections to the B. A. form of standard are, however, these:—

1. It cannot be placed in water with the shell wholly under water or under ice without short-circuiting the electrodes, and, when used as intended, whilst the narrow or bottom portion of the coil is in the water, the upper and more massive portion is in the air, and therefore may be at a different temperature to the bottom portion. Hence arises a doubt as to the actual temperature of the coil of wire. It has to be borne in mind that the limitation of accuracy in such comparisons of standards of resistance is determined by the difficulty of ascertaining temperature, and not in the mere measurement of resistance. Uncertainty as to the actual temperature of the wire to the extent of one or two-tenths of a degree Centigrade renders nugatory elaborate arrangements for very accurate measurement of resistance.

2. The standards, as at present constructed, are liable to another defect. If the standard is being used in melting ice or snow, and therefore cooled to 0° Cent., deposition of dew will take place upon the upper surface, whether it is the ebonite lid or paraffine-wax surface, through which the

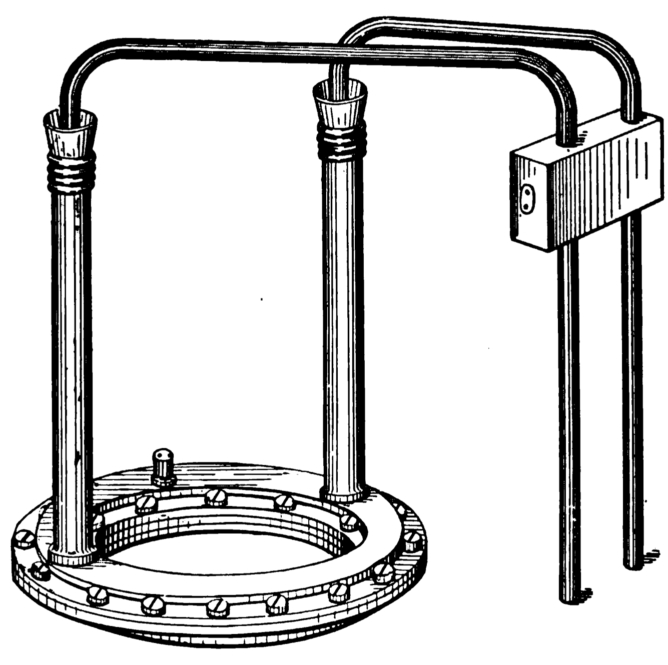


Fig. 1.

copper rod electrodes protrude. The copper rods are originally lacquered or varnished, but when the lacquer wears off, any film of moisture so deposited will short-circuit the electrodes and reduce the observed resistance. In comparing standards in melting ice, either then the whole shell must be as far as possible placed under the melting ice, in which case stirring the liquid may splash water on to the surface of the paraffine, or else the shell has to be only partly immersed, in which case ambiguity exists as to the actual temperature of the coil of wire.

1. Abstract of Paper read before the Physical Society, on November 10, 1888.

These and some other difficulties, such as that of keeping a rather deep vessel of melting ice at a constant temperature, have impressed on the writer the necessity for modifying the form of the standard; and one form which has proved itself to be very satisfactory in use is as follows:—The case or shell which contains the coil is in the form of a ring (see figure 1). This ring consists of a pair of square sectioned circular troughs provided with flanges which can be screwed together so as to form a square sectioned, hollow, circular ring.

From this ring proceed upwards two brass tubes about five or six inches in length. Down these brass tubes pass the copper electrodes or rods, and these rods are insulated from the tubes at the top and bottom by ebonite insulators. The insulator at the bottom of the tube, where it enters the ring, is a simple collar, that at the top has the form of a funnel corrugated on its outer surface. The use of this funnel will be referred to presently. The actual resistance coil is a length of platinum silver wire three-fold silk covered. The silk-covered wire is first baked above 100° C. to dry it completely, and then immersed in melted ozokerit or paraffine.

The so insulated wire is cut about the proper length and laid double or folded once upon itself and then rolled up on a wooden mandrel so as to form a circular coil of diameter suitable to drop into the hollow of the brass ring. The wire being wound double, its coefficient of self-induction is rendered very small. This coil of wire is then wrapped over with white silk and again dipped in melted ozokerit. The ends of the wire are next soldered into nicks in the ends of the copper rods, they having been previously pushed a little way through the brass tubes for the purpose, and afterwards drawn back into proper positions. The coil is then packed into the circular groove, and, after adjusting the resistance to the proper value, the bottom half of the ring is placed over it. A thin washer of india-rubber is inserted between the flanges, and the whole screwed tightly together. The resistance coil is thus enclosed in a thin ring of metal, and can be placed wholly below the surface of water or ice. In order to test the tightness of the joints, a little test pipe is provided on the upper surface of the ring. By placing the ring coil below water and blowing into the test pipe, the good fitting of the joints can be assured. The aperture of this test pipe is afterwards closed by solder or a screw (see figure 2).

Apart from the insulation of the coil itself it will be apparent that the insulation is limited by the amount of insulation resistance secured at the ebonite insulators at the top end of the brass tubes. Any leakage from the copper rod over these insulators to the brass tube destroys to that extent the insulation of the coil. The object of making these external insulators funnel shaped is to prevent surface creeping, due to condensation of moisture on them, by placing paraffine oil or insulating liquid in the funnel-shaped cavity. When this is done, even if dew should collect on the outer surface of the funnels the inner surface is kept dry by the paraffine oil placed in them, the action being the same as that in the well-known Johnson and Phillips fluid insulator.

The ring coils when in use are placed in rather shallow zinc troughs, which can be filled with water, and which are closed with a wooden lid. When so placed the whole of the actual coil or resistance part is down beneath the liquid at one level, where the temperature can be accurately ascertained. The insulators and point of emergence of the electrodes are away up above the level of the water, and well protected from any action which might permit of leakage over them. The large metallic mass of the ring assists in bringing the resistance coil quickly back to the temperature of the surrounding water, and the coil therefore "tests quickly." In all other respects these standards of resistance are as compact and portable, and not more expensive to construct than the old form of B. A. standard, whilst obviating the difficulties which present themselves in the use of the old form in very accurate comparisons of resistance.

It is quite possible to have two or more coils of wire inside the same ring, each coil having its separate pair of electrodes. A useful coil of this form can be made up containing 1, 10, and 100 ohms, so that comparisons can be quickly made at the same temperature with these three multiples of the same unit of resistance.

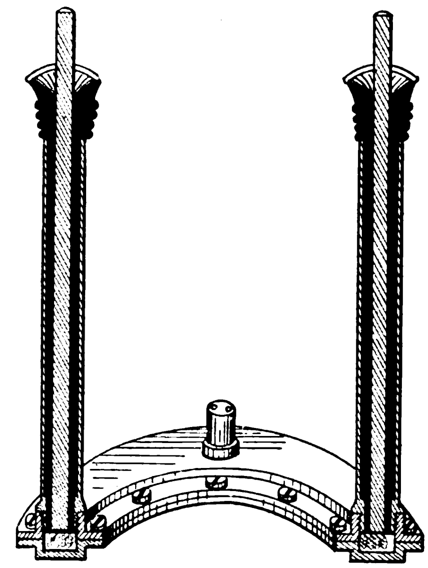


Fig. 2.

The adjustment of the coils to a certain value presents no great difficulties. The wire is in the first instance cut a little longer than required, and its resistance nearly adjusted; when the two ends of the coil have been soldered to the lower ends of the copper rods, the resistance is again taken from the ends of the electrodes. This resistance should be a little greater than the final value required. The middle point of the wire or extreme loop is now stripped of its silk and the loop twisted up with the pliers, the resistance being carefully taken at intervals. When just a very little in excess of the value required the twisted coil is touched with solder, and having been bound over with insulating material the coil is completed. In the construction of standards it is obvious that it is not so important that the resistance should have an exact integer value at any temperature as that its value at some temperature and its coefficient of variation of temperature should be exactly known.

CORRESPONDENCE.

NEW YORK AND VICINITY.

New Roads Proposed.—Mr. Edison's Birthday.—Mr. Edison's Exhibit at Paris.—The "Times" View of the Board of Electrical Control.—The Fulton Street Electric Railway.—A Cable Bill before the Legislature.—Meeting of the Electrical Section of American Institute at the "C. & C." Factory.—A New Motor.—A Yale Professor Objects to Overhead Wires.—Explosion in the Subway.

A New York syndicate has made application to the Edgewater, Staten Island board of village trustees, for a charter for an electric railroad to run from Sea avenue, Clifton, along the South Beach boulevard to New Dorp.

Mr. Edison had a pleasing celebration of his 42d birthday on February 11th. When Mr. Edison entered the great library in his laboratory, the two or three small tables, as many odd chairs, a triplet of well worn rugs, and a dismantled clock, which had constituted the only furnishing of the big room outside the book shelves, had disappeared, and instead was an array of luxurious furniture which would break the resolutions of a mediæval ascetic. Seven heavy, carved oak tables, a score and a half of handsome leather-covered oak chairs, each bearing a carved monogram of "T. A. E."; a big gas-log burning brightly upon a pair of fantastic wrought-iron andirons, and the old clock-face, with new hands and regulated by wire direct from Washington, were the principal

changes. That which claimed Mr. Edison's attention most was a full sized phonograph of gold, silver and steel, provided with the new automatic regulator for adjusting the pressure of the stylus upon the wax cylinder.

Mr. T. A. Edison has been making preparations for the last six months for an exhibition in the Paris Exposition Universelle. He has been allotted 8,000 square feet of floor space in the main building, and here he will show models of all his inventions in telegraphy, telephones, electric lighting, and the phonograph. The principal feature of the exhibition will be an enormous model of an incandescent lamp, 40 feet high, the globe being composed of no less than 20,000 incandescent lamp bulbs. The effect, when the light is flashed, will be wonderfully brilliant, illuminating the entire main building. On either side of this exhibit will be the French and American flags worked out in colored incandescent globes.

The *Times* has the following editorial in relation to the work of the Board of Electrical Control :—

"The work of the Board of Electrical Control, which has been prosecuted against powerful obstacles, is beginning at last to bear fruit. The Broadway and Sixth avenue subways are now being utilized by the Western Union, the fire department and the Manhattan Electric Light Co., and the cheering promise is made that by the 1st of May, all the poles and wires in upper Broadway and Sixth avenue, will probably disappear. Other electric light companies are ordering cables and preparing to make use of the subways. Much of this cheerful prospect is due to the firm stand taken by Mayor Grant, who began his administration by accepting the presidency of the board, and declaring that the law should be enforced. With the city government pledged to the execution of the subway law, those companies which had hitherto defied the Board of Electrical Control have found it politic to fall into line and bow to the inevitable, and the result promises to be the abatement of the overhead wire nuisance in a reasonable time. This will be a victory for the board which it has well earned by its persistent policy of insisting on the execution of the law ; it will be a victory for the people who have for years demanded the burial of the wires, and it will prove a victory for the companies against themselves in the end, for the cost of putting the wires out of sight will be more than repaid by the saving in expense for repairs after every heavy storm."

The contractor who is putting down the Bentley-Knight conduit for the Fulton street road has delayed work for the past few weeks. It is alleged that the delay has been caused by the difficulty in securing right of way for a short distance, and it is now given out that the road will be ready by April 1st. The Bentley-Knight company have completed 13 cars for the Fulton street road, and seven more are being constructed.

At each session of the Legislature a bill makes its appearance giving permission to the surface street car lines to use cable power, but although powerful influences are kept at work it has always met with defeat. The mayor has sent a protest to the Legislature against the bill, stating that he is now considering the question of a solution of the rapid transit problem.

The meeting of the electrical section of the American Institute was held February 6th at the factory of the C. & C. Electric Motor Co., which was formally opened for inspection. The factory is fireproof and admirably equipped throughout. Indeed, it may be doubted if such facilities maintain anywhere else. A 50,000 watt dynamo in the basement supplies power, which is carried by wires to small motors placed so as to secure the minimum of economy.

In connection with the small motor industry which appears to be assuming such large proportions, a motor just placed on the market by the Elektron Manufacturing Co., designed by Mr. Frank A. Perret, is deserving of special mention. The lamination of the field is accomplished in an ingenious manner, and a comparatively high efficiency secured thereby. The armature is wound with double covered silk wire, and there is no lead to the brushes. The mechanical as well as electrical details are most carefully worked out.

Professor Daniel C. Eaton, of Yale University, has presented a remonstrance to the Connecticut Legislature against granting the privilege to a New Haven street railway to string overhead wires, on the ground of danger to the public. Professor Eaton advocates the use of storage batteries.

A terrific explosion occurred in a subway man-hole early on the morning of February 11, at Pearl and Wall streets. It is thought that the heat from the steam heating pipes was indirectly the cause, the insulation of the wires being badly damaged, permitting them to come together and ignite the accumulation of gas.

NEW YORK, February 21, 1889.

.... IN the eternal cycle which with God began, force in a protean form remains constant; and whether it is applied to the uses of man, or whether it is expended in some useless or injurious effect, depends upon how nearly imperfect man can obey the laws of nature in dealing with it.—*E. N. Dickerson.*

PHILADELPHIA.

Novel Installation in the Tabernacle Baptist Church.—Leaving for the Chicago Convention.—Proposed Electric Railway.—Agitating Electric Light for Several Small Cities.—Electrical Patents.

THE Tabernacle Baptist Church on Chestnut street above 18th, which has been closed for several months past while undergoing repairs, was reopened yesterday. The edifice is to be lighted by means of 120 Edison incandescent electric lights, distributed over its extent, placed there under the supervision of Messrs. Walker and Kepler, the agents of the Edison company in this city. The principal grouping of these lights is in a 36-light chandelier in the centre of the church. The entire lighting system is divided into eight sections, each independent of the other, and capable of being lighted or dispensed with separately. On and about the pulpit there are 10 lights on an independent circuit which are operated by the officiating minister who, when desirous of doing so, can light them or put them out by merely touching a button placed conveniently at hand. The organ is operated by a 1-h. p. Sprague motor controlled by the current from the Edison plant. The motor of the organ is so arranged as to produce the most satisfactory results, practical people declaring that its action is superior to that of any former methods employed. There are but 12 gas jets in the entire church. The beautiful fixtures were a present to the congregation from Mr. E. H. Johnson, president of the Edison Electric Light Co., of New York, who formerly resided in this city and was a member of the Tabernacle Church. The church has now one of the handsomest interiors of any in the city. The Edison company have now a large number of lights in operation in this city, and are constantly adding to the number. The Drexel building is supplied with 2,300, the immense sugar refinery of Harrison, Frazer & Co. has 2,900, the Fidelity Trust Co. have 300 lights operated by a plant of their own. In a short time the Bullitt building will be lighted by some 1,600 lights, the City Trust building by 270, and the Keystone bank by 300. In addition to these there are now in operation, lights in a large number of stores in Market and Chestnut streets, as well as private residences on Walnut street.

A number of representatives of the electric light companies in this city left on the Chicago limited express from Broad street station yesterday to attend the convention of the National Electric Light Association, which opens in the Exposition building, in Chicago, on next Tuesday morning. A large number of representatives from New York were on the train, and others will be picked up at Harrisburg and Pittsburgh. Among those from this city were supervising engineer W. D. Marks, president L. D. Brown and secretary Henry G. Bryant, of the Edison company ; John S. Muckle, of the Westinghouse company, and Andrew J. DeCamp, of the Brush company.

For some months, plans for the construction of a passenger railway to take in Haddonfield, Merchantville and the several small towns between them and Camden, N. J., have been under discussion, and it is said that in a few days they will take form. It is stated that negotiations are already pending for the purchase of the old horse railway, with a view to introducing electric motors on at least a part of the system.

A large meeting of citizens of Holmeville, Eden and Langhorne, Bucks Co., Pa., was held at the latter town recently for the purpose of considering the introduction of electric lights into those places. A company was organized to secure a plant, and $13,000 worth of stock was subscribed for. Bordentown, N. J., is also agitating the electric light question.

According to the brokers of this city, capitalists and speculators are turning their attention to electric stocks now.

The following patents were issued to Philadelphians last week. Rudolph M. Hunter, dynamo-electric machine, also apparatus for heating cars by electricity. Francis J. Clamer and J. H. Hendrickson, protecting negative plates of electrical batteries.

PHILADELPHIA, February 18, 1889.

BOSTON.

The Police Signal System.—The Electric Club.—The Electric Light Interests at Dedham.—The City and State Government's Interest in Electrical Industries.—Matters of Interest Connected with Electrical Traction.—The Snow Storm.—The New Building for the American Bell Telephone Co.—Petition of American Bell Company for Increase in Capital Stock.—The Bell Telephone Co.'s Exhibit for the Paris Exposition.

IT was expected that before this time the police signal system would be in full operation in all sections of the city. But difficulties have been experienced and delays occasioned, so that the work of construction, which is conducted by police-lieutenant Goodwin, will not be completed for a few months yet. The police districts which are still without the system are division 2, city proper ; division 7, East Boston ; division 10, a part of Roxbury ; division 11, Dorchester ; division 12, City Point, South Boston ; division 13, West Roxbury ; division 14, Brighton, and division 16,

Back Bay. The wires and boxes are about ready for use in East Boston, Roxbury, Dorchester and Brighton, and the system will be operated in those divisions just as soon as stables and wagons can be built. The work of construction is slowly going on in South Boston (City Point) and in West Roxbury and the Back Bay. According to Lieutenant Goodwin, the board of police has not decided as to the advisability of having a patrol wagon for the Back Bay. The boxes will be a great adjunct to the police service of the business district, for it should be remembered that they are not only of value in troublous times, but are excellent preventives of negligence, every patrolman being required frequently to visit the boxes on his route, send in the "on-duty" call, and telephone unusual incidents to the station house. By their aid a police sergeant can sit in the station house and know at almost any time of the day or night where an officer can be found. Should a wagon be needed, it can be called from another division.

About 200 keys of signal boxes have been issued to as many citizens by the captains of the different divisions. The keys are given to citizens who make application for them, but these citizens must be personally known to the police as men of good character and of excellent standing in the community. Thus far but few citizens who possess keys have had occasion to signal for the police.

The Boston Electric Club, at their new quarters, No. 7 Park street, was entertained on the evening of the 6th inst., by Hon. Richard J. Monks on "The History and Growth of Artificial Lighting." Mr. Monks exhibited several valuable and curious appliances used, particularly in ancient artificial lighting, not the least interesting of which was a finely wrought copper lamp of Persian origin, and claimed to be at least 1,000 years old. A part of the address was identical with that given before the Boston University two years ago. The concluding portion referred more particularly to electric lighting, and was interesting. Subsequent to the address the members and friends passed a pleasant hour or two in social intercourse in the new rooms.

The following items concerning Dedham, this state, are a fair sample of what is going on in electric light matters in the towns of New England :—

The Dedham & Hyde Park Gas and Electric Light Co. started up its electric light plant in Dedham, on the night of the 30th ult., lighting up its office and the office building. The company is now prepared to supply electricity for public and private use as soon as permission is granted by the selectmen to extend their wires through the town.

The selectmen gave a hearing on the 7th inst., on the petition of the Dedham Gas & Electric Co., for leave to erect posts and wires in the highways. After listening to the arguments of George Fred Williams, counsel for the company, the matter was laid on the table, as a similar petition had been filed earlier by the Dedham Electric Light Co. It was decided to hold a public meeting in the lower Memorial Hall, next Thursday evening. The Dedham Gas & Electric Light Co. illuminated Memorial square in a brilliant way by means of five electric lights placed in front of its office and the adjoining buildings.

There was a hearing before the state committee on manufacturers on the petition of the Dedham Water Co. to furnish electric light and power. John R. Bullard, treasurer, said it was the purpose of the company to supply electricity by the underground system. There were two other petitions before the selectmen, but he believed that it was for the interest of the town to have as many competitors as possible. One of the petitioners was the Dedham Electrical Co., which has no visible capital and the other the Dedham and Hyde Park Gas Co. Both these propose using the Thomson-Houston system. W. A. Feltee, manager of the gas company, said that two of the directors of the water company opposed the petition before the committee, and that it was presented without the consent of the stockholders. The legislature, he said, recognized the right of gas companies to furnish all manner of lighting, and its company had its plant ready and could put it in operation within 30 days.

Our solons at the State House are full of recommendations concerning electrical matters—a bill to regulate telephone rates ; one that Frank W. Ames and others be incorporated as the Boston Electric Elevated Railroad Co.; one by Mr. Gleason, of Plymouth, as to authorizing the gas commissioners to issue temporary licenses for the laying of electric light wires ; one by Mr. Farren of Stoneham, as to examining the effect of electric street car wires upon the safety of life and property.

Our electric railway from Park square out to Brighton, continues to be the pet of the town ; it had its first trial with a snow storm on the 20th ult. Unfortunately the storm found the West End road not fully prepared for the contest, as the electric ploughs and track sweepers are not yet finished, and arrangements for the use of the ordinary horse ploughs over the 13 miles of electric track were not completed until the middle of the forenoon. The first cars from Oak square ran all right until the conduit system was reached on Beacon street, the little rail ploughs and brushes sufficing to clear the track in good order. The conduit, however, bothered some, and car after car reached it only to stop, until eight cars were standing all in a bunch. The ice which filled the little slot was finally dug out by men with shovels and picks for some little distance on Beacon street, and the cars then moved along rapidly and without trouble, and the first car reached Park square at nine o'clock, rapidly followed by others. In the meantime a common street railway plough, drawn by six horses, was sent over the track to Coolidge corner, so that on the return the electric cars spun along merrily. The overhead system appears to have been the most reliable under the disadvantages of this storm ; but when the electric snow ploughs, with their specially constructed mechanism for clearing the conduit, are ready for use it is believed that the entire line will work satisfactorily. As horse cars were all running with four horses after the tracks had been cleared by the ploughs, while the electric cars run along easily with heavy loads and cleared their own tracks, the advantages of electricity were evident.

As a precaution against stoppage by day on account of the snow fall, the electric cars of the West End, Brookline and Brighton lines were run all night on the 11th, and in the morning following the tracks were in good condition for travel. Cars were run at frequent and quite regular intervals throughout the forenoon, and were well patronized. As the employés become more and more familiar with their new duties, the absence of hitches becomes more apparent. The only obstruction was the usual one, not caused by the storm. At about 11.15 o'clock four cars were stopped five or ten minutes on the conduit system at Chester park and Beacon street, by the burning out of two "ploughs." These were taken aboard, and the derelict cars were propelled by the cars following them until the overhead section was reached, and they resumed their course.

It is proposed to build an electric road from Lynn to Nahant, and the $60,000 required for the purpose has been subscribed, several prominent residents of Lynn and Salem being interested in the enterprise.

The American Bell Telephone Co. have petitioned the legislature for an amended charter, to wit : that their capital stock may be doubled, increased from $10,000,000 to $20,000,000. In consequence of this, the stock has advanced from about 207 to 225. The work upon the new building for the telephone companies, progresses slowly; the foundations are being solidly laid. A glance at a perspective view (in water color) of the new building, discloses a tall, massive and fine facade fronting on two streets, Milk and Oliver. The building will contain the American Bell offices, the New England Telephone & Telegraph Co.'s offices and the Boston Telephone Exchange, the Long-Distance Telephone offices, and leave rooms and offices for rental.

The Bell company have completed a very interesting exhibit of telephones and telephonic apparatus for the Paris exposition, comprising early telephones, bells, Edison mototograph, etc. The exhibit will be in charge of Mr. W. D. Sargent, of Brooklyn, N. Y.

BOSTON, February 16, 1889.

CHICAGO.

Death of Mr. George L. Phillips.—Temporary Stoppage of the City Lighting Service in the Town of Lake.—Two Trains on the Chicago, Milwaukee and St. Paul Railway Equipped with Electric Light Plants.—Lighting the North Side Street Cars Automatically as the Tunnel is Entered.—A Rumor that the Van Depoele Company Proposes Introducing an Alternating Current System. The City Lighting Plant for Elgin, Ill.—The Matter of Reduction of Telephone Rates in the Hands of the Legislature.—The United States Electric Lighting Co. Awarded the Contract for Increase of Plant in Court House.—Electrical Interests at Lake View.—The Cushman Company Announces an Appeal to the Supreme Court.

GEORGE L. PHILLIPS, president of the Chicago Telephone Co., and the Central Union Telephone Co., died of malignant typhoid fever at his residence in Edgewater, a suburb of Chicago, January 29th. The circumstances were unusually sad. Mr. Phillips, soon after the holidays, left Chicago, to accompany his daughter, a young lady 17 years of age, to New York, where she was attending school. Father and daughter were at the time apparently in perfect health. After a short stay in the east, Mr. Phillips returned to his home. He felt slightly ill on his journey westward, and as soon as he reached Edgewater typhoid fever of a malignant type was developed. News was soon received that Miss Phillips was seriously ill of the same disease in New York. Mrs. Phillips immediately left for the east, and a week after she had reached her daughter's bedside the latter died. The remains were taken to the family lot in Dayton, O., for burial. Death had afflicted the family of Mr. Phillips' brother in Dayton, just before this time. Two children had died suddenly. Mrs. Phillips accompanied by her brother-in-law, Charles A. Phillips, hastened to Edgewater. Mr. Phillips' condition was most precarious, and the news of his daughter's death was carefully concealed from him. He grew steadily worse, and on the fourth day after his wife had reached home, succumbed to the disease. He leaves a wife and four daughters.

Mr. Phillips was born in Dayton, in 1845, and was the son of T. A. Phillips, a cotton manufacturer in that city. He attended

the University of Michigan, at Ann Arbor, in the class of '67, but left before graduation to enter the army. He subsequently entered his father's business and was a member of the firm for several years. During this time he organized the Dayton American District Telegraph Co. and the Cincinnati American District Telegraph Co He continued to be president of the latter corporation until his death. He organized the Dayton Telephone Co., and his services there were so efficient that he received the appointment to take charge of the Boston Telephone Exchange. Subsequently he acted as assistant general manager of the American Bell Telephone Co., with headquarters in Chicago. He left this position to take a European tour. He returned in 1886, and was elected president of the Central Union Telephone Co. A little over a year ago he became president of the Chicago Telephone Co.

It has been noted in the letters from Chicago, that the last year was one filled with controversies between the city government on the one hand and the Chicago Telephone Co. on the other hand. The city council endeavored to regulate the business of the corporation and the latter very naturally resisted. The company was without an ordinance warranting it to transact its business in the city. The year for the company was a struggle against encroachment by the aldermen. The duty of solving the problem fell on Mr. Phillips, and he secured a victory by obtaining a franchise without conceding any of the essential points for which the company had been fighting.

Mr. Phillips was a man of splendid physique, and full of energy. Personally he was of a kindly nature. On first acquaintance his manner was extremely formal and unbending, but behind an exterior rather severe he preserved a feeling of kindness and friendliness. His associates in the two companies of which he was president, were attached to him by the strongest ties of friendship, and they are of one opinion that he was the ablest executive officer of a telephone company in the country.

In speaking of the death of Mr. Phillips, an officer of the Central Union Telephone Co. said to the representative of the ELECTRICAL ENGINEER:—"I have been connected with corporations for 30 years, and have been associated with a number of able executive officers, but I have never seen such a president as Mr. Phillips. He was a man of the most marked executive ability and he had a large fund of knowledge, tact, experience and talent which enabled him to grapple successfully with the many perplexing problems peculiar to telephone work. His talent in this direction was developed at a time when there were few men in the country who thoroughly comprehended the business, so that his services have been of extraordinary value in connection with the development of telephony in this country. This company and the Chicago Telephone Co. have suffered a great loss. His place can never be filled. His death comes to us all as a personal bereavement."

There has been a curious state of things in the Town of Lake, which adjoins Chicago on the southwest. Its streets are lighted by arc lights operated from the circuits of the Chicago Arc Light and Power Co. The trustees of the town became engaged in a controversy with the gas company, and refused to put any money into the illumination fund lest it should be drawn upon by that corporation. The electric light company suffered at the same time, as there was no fund which could be employed in defraying its bills. The electric light company's bill grew greater and greater. The officers received in answer to their demands for money, letters assuring them of the continued respect of the trustees, but nothing in the form of checks. Matters soon came to a crisis. The trustees were informed that unless money were forthcoming on a certain day the electric light service would be discontinued. The trustees still hesitated and the supply of current was shut off. A murder was committed and several burglaries followed, and as a result the trustees found their constituents criticising them in no uncertain terms. A compromise was effected. A large sum of money was paid to the electric light company, and the Town of Lake again rejoices over the fact that it has its streets well illuminated.

The Chicago, Milwaukee & St. Paul Railroad Co. has adopted on two of its trains running into Chicago, an electric light system. Each plant consists of an Eickemeyer dynamo, a Brotherhood engine and a set of storage batteries. Up to midnight the lamps throughout the train receive their current directly from the dynamo. After that time the storage batteries carry the load. The installations were made by Leonard & Izard. The system will probably be extended to other trains in the near future.

A cable car on the north side, has been wired for incandescent lights. The intention is to illuminate the car as it passes through the La Salle street tunnel. The current will be conducted to the car by an overhead wire, along which a trolley wheel will run. Connection will be made automatically as the car enters the tunnel and will be broken as it passes out.

There is a rumor current that the Van Depoele company proposes to put an alternating current system on the market at an early day. Representatives of the company neither deny nor affirm the report.

Mention has been made from time to time of the fight over the contract for the electric light plant for the city of Elgin, Ill. A plant has been in use there for several years, but when the council asked for bids there was the usual scramble for the contract. Charges of bribery too were made without hesitation. The contest is now over. The council has voted to buy the local plant and retain the tower system of lighting.

Like most legislatures throughout the country, the lawmaking body at Springfield, Ill., has wrestled with the "telephone question" in all its details. The legislators are possessed of the idea that they are face to face with a problem which demands instant solution. A number of bills contemplating a general reduction in rates has been introduced. All the measures are of substantially of the same character. They propose reductions according to which rentals would range from four to six dollars per month. The bills are penal in character. The offense according to the measures for violating the provisions of the proposed acts by overcharge is a misdemeanor. One bill has also been introduced delegating to municipal councils the right to regulate telephone rentals. It is scarcely necessary to remark that the Chicago Telephone Co. is especially aimed at by all the legislative marksmen. The rentals in Chicago are $125 per year, and if any of the proposed measures become a law it would be the greatest sufferer. Officers of the company state that rather than submit to the conditions of most of the bills the company will cease to transact business. It should be added that they do not anticipate the passage of any of the sweeping bills.

The United States Electric Lighting Co. has been awarded the contract for increasing the incandescent plant in the Cook County court house, from 1,000 lights to 1,500 lights. The dynamos now in use will be replaced by larger generators.

A bill has been introduced in the legislature at Springfield, authorizing the city of Lake View, which adjoins Chicago on the north, to establish a municipal electric light station or gas works.

The Lake View Telephone Exchange of Chicago, has been incorporated. The capital stock is $72,000, and the incorporators are L. D. Tuttle, J. M. Cleaver and W. F. Wiemer.

The Cushman Company, of Chicago, will carry its appeal from the injunction granted by Judge Blodgett in favor of the Bell Telephone Co., to the United States Supreme Court. A motion for a rehearing was denied by Judge Blodgett recently.

CHICAGO, February 20, 1889.

SAN FRANCISCO.

A Society of Electricians in San Francisco.—The Phonograph Company.—State Legislation concerning Telegraph and Telephone Companies.—Rivalry of the Western Union and Postal Telegraph Companies.—Pneumatic Tubes to be Employed for Local Delivery by the San Francisco Post Office.

SAN FRANCISCO has determined to have a society of electricians which intends to pursue the same course adopted by the eastern societies. It was organized permanently last week by electing N. S. Keith president, and O. Brooks vice-president, adopting a constitution and by-laws similar to those of the Buffalo, N. Y., organization. It is to be hoped that good results may ensue from thus associating, interchanging ideas and discussing methods and theories. Over fifty men have already signed the roll, and it is intended to merge this organization with that of the Mechanics Institute of this city, thus placing an excellent library at the service of the embryo-electrical engineers.

A determined effort is being made to float the phonograph stock here; all the clerks in the Telephone and District offices have received shares gratis.

The legislature of this state is trying to make telegraph and telephone companies common carriers, and thereby hold them responsible for all errors and omissions. Superintendent Jaynes, of the Western Union company, is most of his time at the Capitol working against the bill, but he will have a hard fight of it, as public opinion is anything but favorable to his company in this state; while his own admissions in the *Examiner* of this city a few weeks ago are embarrassing. Rivalry is running rife in this city between the Western Union and Postal companies. Branch offices are to be seen at every corner where they are *vis-a-vis*, with their banners floating in the air. A few weeks since the Western Union thought a block or two nearer Market street preferable, whereupon the Postal erased "Postal" off their window, and now it simply reads "Telegraph Office."

The efforts of the Postal company to drive the older company will only end in loss to themselves; although they are building to Los Angeles and southward and expect to reach that city in a few weeks. They are getting there when Southern California is settling down to a fundamental basis, the "boom" having subsided. They will find, too, that when the Western Union will use Wheatstone to Portland, Oregon, and to Los Angeles, that the old company will reduce rates to such a proportion that the young company cannot afford to employ a decent operator at a respectable salary. At least it is presumable that such would be the tactics of a great rival to freeze the weaker out. There is some talk of a bill in the legislature making all rates within the state 25 cents for twenty words and five cents for every extra ten words.

Manager McRobie, of the Western Union, has done herculean work since his arrival here. Manager, cashier and general information bureau, he has worked far into the night and to him the public is indebted for a prompt and more accurate service than they have been accustomed to heretofore.

The pneumatic tube system will soon be introduced into this city for delivery of letters in conjunction with the post office department. This will prove a crusher to district systems, and it is about time the public was relieved of this incubus.

SAN FRANCISCO, February 16, 1889.

MONTREAL.

The Carnival; Electric Illumination of the Ice Palace.—The Brush Incandescent System in the New Building of the New York Life Insurance Co.—The Edison Company to Light the New Temple Building.—The Royal Company to Light the Imperial Bank Building.—Other Electric Lighting Notes.—Success of the Westinghouse Plant at Cornwall.—Train Lighting on the International Railway.—The Federal Telephone Co.

THE excitement of the Carnival is over, and the usual quiet reigns again. As a contemporary remarks in an opening address, "We are a hyperborean people of cheerful outward appearance, but are in reality wrestling with an unfavorable climate to make a living."

The electric lighting of the Ice Palace was very effective; 50 arc lights illuminated the interior, the castle presenting a beautiful opal surface at night, well worthy a trip to Montreal to see. The climax was reached in the bombardment of the castle. At nine o'clock 1,500 snow shoers, bearing torches, wound down from the mountain, and on approaching the castle commenced the attack, discharging volley after volley of Roman candles, sky rockets and colored lights. The garrison made a stout resistance with like weapons, but after 20 minutes' resistance were compelled to capitulate.

The New York Life Insurance Co. are building a handsome eight-story brown stone office building on the Place d'Arms. It is to be lighted by the Brush system of incandescent lighting. Wm. B. Parmelee is installing the plant, which will consist of 810 lamps. The wiring is of Grimshaw wire throughout. The dynamos are to be run by two Mackintosh and Seymour compound engines of 60 h. p., and the steam will be supplied by three Babcock and Wilcox boilers. The building and installation will be one of the most complete in the city.

The Temple building being erected on St. James street, is being wired by the Edison company for 680 lamps.

The Imperial Insurance Co.'s building, remodeled from the Consolidated Bank building has been wired by the Royal company for 575 lamps.

The Edison company report sales of 75 lights to the *Free Press*, London, Ont., and a 10 h. p. motor to Patterson and Corbin, St. Catharines, Ont. The 600 lights mentioned in last month's letter sold by the Edison company were put in the Long Point (Quebec) asylum.

The Royal Electric Co. report sales of 40 arcs to the London, Ont., company, 35 arcs to the St. Catharines company, 50 arcs to the Quebec company and 25 arcs to the Moncton, N. B., company.

The Westinghouse company at Cornwall, are very much pushed to keep up with the demands for their light. They are peculiarly favorably situated, in that the local gas company recently adopted water-gas and the incandescent comb system of gas lighting. Users, especially cotton factors, are afraid the comb will break and fall into the fabrics below, igniting them. The insurance companies have also increased the rates for its use, and consequently the gas company are in a very bad way.

The City of Toronto has awarded the contract for an increase of 200 arc lamps to the present company, the Toronto Electric Light Co. The International Railway Co. (government road) are preparing to light their trains running out of Quebec by electricity.

The Craig people who have a municipal plant in St. Cunegonde, a suburb of Montreal, have extended their system to Côte St. Antoine, another suburb, and are to light that municipality.

The Federal Telephone Co. are pushing their system and propose to be in operation in May.

MONTREAL, February, 20, 1889.

.... WHEN the great Creator, in the construction of this world separated the carbonic acid of chaos into its two constituents, and stored away the carbon for the use of man, while the oxygen was liberated in the envelope of the earth, ready to again combine with the carbon, and again produce the force which had been expended in disuniting them, the problem presented to imperfect man was the production of so much force, by again uniting these dissevered elements, as had been expended in separating them. The plain injunction given to him is: Be economical of these resources, for they are limited.—*E. N. Dickerson.*

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall street, New York city.*

[103]—As it has become the fashion amongst our best technical colleges to found a course in "electrical engineering," let us heartily applaud the recognition of the demand for higher training in our profession. Then let us examine the treatment that the electrical course should receive and is receiving.

Ten years ago the most sanguine mind could scarcely have conceived the incandescent electric light as a public necessity, and electric transmission of power was unborn. Since 1880, the growth of the industrial applications of electricity has been solid and continuous. Gathering new vigor each year they have rapidly gained a high rank amongst the industries first in utility and public favor, and amongst those producing dividends on invested capital. The magnitude of the growth can be understood, and the situation grasped only by those who are engaged in helping it forward—the practical men and engineers. Those not in intimate contact with the profession tell us "all mechanical engineers are electrical engineers," which is all folly. That an "electrical engineer must first be a mechanical engineer" has the ring of truth, for he must be a thorough electrician with the instincts of a mechanical engineer.

The installation of profit making electric plants that will embrace the necessary factors of safety, convenience and economy in operation, with the least original outlay for plant, as fully requires the skill of a specially trained engineer as any undertaking of the civil or mechanical engineer. His training must be founded on the broad basis of general engineering, but in practice he must be a specialist—an *electrical* engineer.

The basis for founding courses in electrical engineering is evidently good, but our colleges apparently fail to grasp the distinctive features of the profession. It is usually tacked to the department of mechanical engineering or of physics, and in consequence either does not receive due attention or active practical treatment. The industrial applications of electricity are of sufficient magnitude to demand skilled engineers trained in a college department founded purely for instruction in electrical engineering, where the best engineers are given to making the instruction cover the demand, causing it to be practical and useful. Let the electrical engineer take a thorough, distinctive training, at the end of which he can stand for his profession as an E. E.; not a pseudo mechanical engineer, nor a bachelor of all the sciences.

D. C. JACKSON.

Kearney, Neb., Feb 9, 1889.

LITERATURE.

Fortschritte der Elektrotechnik. Unter Mitwirkung von Dr. M. Kiliani und Dr. E. Pirani herausgegeben von Dr. Karl Strecker. Erster Jahrgang. Das Jahr 1887. Berlin, VERLAG VON JULIUS SPRINGER, 1888.

THE pains-taking labors of Dr. Strecker and his able assistants, together with the enterprise of Herr Julius Springer, are giving to professional electricians and students a work of the utmost value in the Fortschritte der Elektrotechnik, of which four parts, covering the year 1887, have been in our hands for some months.

The work is a systematic guide to a large mass of contemporaneous electro-technical literature in German, English, French and Italian; the scheme including a compilation of titles—of papers, articles and notes—from leading electrical, engineering and other scientific periodicals, proceedings of technical and scientific societies, and from German, English and American patents; followed by brief descriptive notices of the most important of them.

The material of the work is classified in five sections, and 17 sub-divisions, namely :—

Section A.—*Electro-mechanics.*
1. Dynamo-machines, Electro-motors, Regulators.
2. Distribution and Conduction.
3. Electric Illumination.
4. Electric Transmission of Power.
5. Various Applications of Electricity.

Section B.—*Electro-chemistry.*
6. Primary Batteries.
7. Secondary Batteries.
8. Applications of Electrolysis.

Section C.—*Electrical Communication and Signaling.*
9. Telegraphy.
10. Telephony.
11. Electric Signals, Registering Apparatus and Clocks.

Section D.—*Measurement and Scientific Research.*
12. Galvanism (current electricity), Current, Potential and Resistance.
13. Magnetism, Methods and Instruments of Measurements, Induction, Self-induction and Capacity.
14. Lamp Measurement, Photometry, the Electric Arc.
15. Electro-chemistry, Electrolytes, Polarization.
16. Physical Researches in Electrology.

Section E.—*Terrestrial and Atmospheric Electricity.*
17. Earth Currents, Lightning Rods, Statistics of Thunder Storms and Lightning Strokes.

The references are numbered *seriatim* and amount to no fewer than 4,461 for the year 1887, and are followed in the fourth and last volume for the year by a list of 32 new books, with references to reviews and notices of each, and descriptive notes on the part of the authors of the "Fortschritte."

In the arrangement of the book the list of references comes first in each section and is followed by the notes of description or comment, each of the latter being numbered in the margin to correspond with its reference in the title list. Many of these notes are extended and in some cases include illustrations. A subject index and an index of authors are furnished in the last quarterly volume for 1887. The information contained, classified and arranged for use in this periodical publication can not fail to be extremely useful not only to students and investigators, but to practical electricians and electrical engineers. It should find its way into every electrical library.

It will be of much value to solicitors of patents and patent lawyers in facilitating researches into the "state of the art" in important cases. Such a summary of electrical literature, say of 1879, would be highly prized at this time.

Treatise on Patent Estate. Comprising Nature, Conditions and Limitations of Interest in Letters Patent. By THOS. B. HALL. Cleveland: INGHAM, CLARKE & Co., 1888.

It is a great pity that the author of this useful and otherwise generally excellent little book, of which the profession and the public have long felt the need, could not have written it in English, and thereby materially increased its sphere of usefulness, and his reputation as a text-book writer. We remember few law books, the examination of which has so much interested us, and yet at the same time has caused us to feel so keenly our ignorance of foreign languages. It is a still greater pity that Mr. Hall's publisher could not have published an English translation of this work for we feel sure that it would have met with a larger demand than the original. It passes comprehension how a modern law publisher could have seen fit to publish this book in its present form, were not the material treated comparatively novel, the need of a treatise on the subject long felt, and the method of treatment substantially satisfactory. For the publishers of this book there can be no excuse. For the author there can be but two excuses; either his publishers have published what he chooses to call "developed outcome of notes made for personal reflection" (assuming that one knows what that means) without giving him an opportunity of revising them, or else he has sat so long at the feet of the German jurists of the last century that he has been unable to shake off the formalism of their style and method of oration. Against this second excuse militates this author's method of quoting from the Pandects, on pages 100 and 101. A German Pandectist would not have failed to give the precise place where the citations were found. Nevertheless the book is extremely useful to every patent lawyer. Its arrangement is concise and it covers a peculiarly interesting and almost untrodden field. For the practicing lawyer it is a handy series of briefs ready made, upon the subjects treated of in the several chapters. With this book in the hand, assisted by a good dictionary, the practitioner has a much more general synopsis of the law of property in patents, than it has hitherto been possible to find. Each topic is treated carefully and conscientiously. English and American cases are cited and liberal quotations given, and while we do not agree with the author in some of his views, we cannot help praising his concise method of arrangement. The book contains five chapters:—The Object of our Patent System; Property Rights in Patents; Profits of Property Rights in Patents; Partition of Patents, Accounting between Part Owners; Limitations of Sectional Grants. The reviewer is aware of no work in which any attempt is made to treat systematically these subjects, and particularly those of the second and seventh chapters. The scope and extent of property rights in patents is fully discussed, and cases are freely cited, but the conclusions reached is unsatisfactory, in that as a result of his reasoning the author concludes that "property right of patents would seem to rest in claim in law, to debarment in fact of making, using and vending the invention."

Judge Taney expresses the author's meaning much more clearly in Bloomer *v.* McQuewan, 14 How., 539, where he says: "The franchise which the patent grants, consists altogether in the right to exclude every one from making, using or vending the thing patented, without the permission of the patentee. This is all he obtains by his patent."

In considering the profits resulting from the exercise of patent rights, what the author chooses to call "profits of patent" an attempt is made in the third chapter to distinguish between a so-called "debarment in law of making, using and vending an invention," and a "debarment in fact." The latter the author claims is produced by the former, and being as he says a "primary product though incorporeal and negative, yet being a debarment in fact," is more appreciable by bodily sense than the legal abstraction that produces it." This primary product or incorporeal right is capable of being converted into money, and hence a property attribute is given to a patent. The distinction would seem to be artificial, not founded on sound reasoning and quite needless, as the mere money value of a patent lies in the property itself without reference to the particular nature of the same. The author's views are, however, interesting, and worthy of careful perusal.

The chapter on limitational grants, handles as satisfactorily as is possible in such small compass a subject which bristles with uncertainties, and is a very useful digest of the cases on this subject. In our opinion, a serious mistake has been made in citing Supreme Court cases, in the body of the book from Whitman's Patent Cases, and not from the standard reports. The book is well printed and excellently indexed, and is worth its price many times over to every patent lawyer.

PAMPHLETS AND CATALOGUES RECEIVED.

Bulletin of the Agricultural Experiment Station, Cornell University: College of Agriculture, III. and IV., November and December, 1888. Contents, III.—The Insectary of Cornell University; On Preventing the Ravages of Wire-Worms; On the Destruction of the Plum Curculio by Poisons. IV.—Growing Corn for Fodder and Ensilage; Economic Seed Manure.

Second Report of the Board of Electrical Control for the City of New York—December 21, 1888. Contains Statistics of Subway Work; Rules and Regulations of the Board and some illustrated descriptive matter. 79 pages, including Appendices.

Weston Standard Direct Reading Voltmeters and Ammeters for Direct Current Circuits. Weston Electrical Instrument Co., Newark, N. J. A circular descriptive of Mr. Weston's new voltmeter with list of the several types offered, and an announcement of the near completion of a similar series of ammeters.

Illustrated Price-List of the Taper Sleeve Pulley Works, Erie, Pa. Gives descriptions of pulleys, couplings, etc., handsomely illustrated, with priced lists of the various sizes and styles supplied.

POINTERS.

.... THE man of true genius never lives before his time; he never undertakes impossibilities, and always embarks in his enterprise at the suitable place and period. Though he may catch a glimpse of the coming light as it gilds the mountain top, long before it has reached the eyes of his contemporaries, and though he may hazard a prediction as to the future, he *acts* with the present.—*Joseph Henry.*

.... IN the history of the development of the steam engine one curious phenomenon deserves to be mentioned, and that is the attack upon James Watt and his laws of steam by the government of the United States during the rebellion, when vast sums of money were expended in building steam engines. At that time the government officially pronounced its judgment of condemnation upon the laws of Watt, and published that judgment in a book which was distributed to the engine builders and engineers of the country as the authoritative decision of the United States.—*E. N. Dickerson.*

.... THE scientific recluse, shut up in his own thoughts, as in a cell, and magnifying the grandeur and importance of his own work at the expense of that of others not exclusively devoted to research, is more nearly a modern imitator of the monastic original than most persons are apt to suppose.—*Alpheus Hyatt.*

.... STUDY the laws of nature, which are the thoughts of God, and do not attempt to rebel against them. We cannot create new laws or produce force. Obedient to these laws, work on in adapting them to the uses of man; and the time is not far distant when steam power, at the rate of three-quarters of a pound of coal an hour a horse-power—or its equivalent in petroleum—and with 95 per cent. dynamos, the electrician will take possession of the whole field, wherever horse-power is to be used for the convenience and elevation of men.—*E. N. Dickerson.*

.... THE coal deposits, when once exhausted, cannot be renewed; and the existence of civilization on the earth in its present form depends upon the supply of available carbon.—*E. N. Dickerson.*

.... THE future before men of the electrical profession is brilliant indeed. The doors were opened wide by Henry and Faraday, and already we have explored far beyond their imagination.—*E. N. Dickerson.*

NEWS AND NOTES.

THE TELEPHONE INTERFERENCE CASES.

An Important Decision by the Commissioner of Patents.

McDonough v. Gray v. Bell v. Edison.
Decided February 23, 1889.

STATEMENT.

Statement of the litigation growing out of the several interferences declared between the patents granted to A. G. Bell and the applications of later applicants; the inventions distinguished and compared with the previous state of the art, and the decisions rendered by the various tribunals in the Office considered and discussed.

1. *Gray's Petition to reopen.*

Held that the petition "is of no avail for any purpose whatever;" that Gray proposes no new evidence as to dates, nature, or the character of his own invention; that it was conclusively shown in the evidence that Gray, at the time of filing his caveat, while having a conception of the telephone, did not understand the invention, and was unable to explain the mode of its operation; that he adhered to the idea that articulate speech must be transmitted upon the multiple-telegraph principle; that he positively conceded that he did not reduce his invention to practice for a long time after the issuance of patent to Bell; that he regarded the invention patented to Bell as trivial, and called it a "scientific toy," and turned his attention to other and, in his opinion, more important inventions; that he negligently omitted to file his application for a patent until two years after the grant of Bell's patent and was then stimulated to do so only by other parties, who had acquired an interest in his inventions; and that his present petition, filed without notice to the adverse parties, was delayed for 3 years and 5 months after the decision of the examiner of Interference awarding priority to Bell, and was then accompanied by a request that it should not be acted upon until further motion was made.

2. *Charges of Fraud.*

For reasons stated, the charges in Gray's petition that Bell had fraudulently secured access to his caveat, purloined his invention, and interpolated a description thereof in his application *Held* not sustained.

3. *Priority of Invention and Validity of Bell's Patent.*

Held that the decision of Commissioner Butterworth, of March 3, 1885, was elaborately considered and deliberately rendered, and that a rehearing could only be justified upon clear and satisfactory evidence showing in such decision error in the conclusions of fact or in the application of the law, and that evidence could be produced establishing that Gray could antedate Bell's invention, that he could prove a prior conception and reduction to practice, or that, having made an earlier conception, he had diligently prosecuted it to a reduction to practice. In the absence of showing the existence of such evidence upon the testimony filed before and considered by the various tribunals in the Office, *Held* that "the award of priority of invention was justly given to Bell," and, in view of the construction given by the Office and the courts to the patent, the grant was properly issued, and the protection afforded the inventor was authorized.

4. *Extending the Monopoly.*

The public has a direct and immediate interest in the further prosecution of Gray's application for a patent. If the award of priority given to Bell can be vacated and set aside, it should only be done upon a showing of merits that would entitle Gray to a patent. Such patent would run for a period of 17 years from its date, and would dominate and control all devices relating to the telephone for another period of 17 years. The effect would be to subject the public to a renewed monopoly in all nearly, if not quite, thirty-four years. Such result would be in contravention of the spirit of the statute, and, in view of the liberal provisions of the patent system, cannot be tolerated except when the inflexible rules of law a d ju tice compel it, especially in the present case, wherein it is clearly shown that the Bell Company is the "equitable if not the legal owner of Gray's telephone inventions."

5. *Titles and Rights under Assignments.*

The Commissioner has no equitable jurisdiction over the rights of parties claiming under assignments and grants of inventions and patents. He cannot set aside or vacate such instruments, nor can he recognize equitable rights growing out of transactions between inventors and applicants and other parties. While the Commissioner is authorized to recognize formal legal assignments, and when they have been filed in the Patent Office before patent issues may give the assignee control of the management and prosecution of an application and direct the patent to issue in the name of the assignee, yet he cannot recognize equitable rights under executory or other equitable contracts; but where the relief asked, as in a petition for rehearing, is founded upon an alleged state of the title to the invention, the Commissioner possesses the power to determine the allegation as to title in order to exercise his discretion in granting or refusing the relief.

1. *McDonough's Petitions.*

As to the petition of McDonough that he be allowed to demonstrate the operativeness of the make-and-break principle, the Commissioner holds the decisions of his predecessors are conclusive on that question; that McDonough never claimed to be the original inventor of the telephone, but a mere improver upon Reis's instruments; that he accepted and still accepts the make-and-break system of Reis as the foundation of his invention; and, in view of the settled judgment of the Patent Office that speech cannot be transmitted by an instrument which operates solely by the making and breaking of the circuit, and also in view of the fact that the Supreme Court of the United States has also definitely settled this question with reference to Reis, he must regard the matter *res adjudicata.*

2. *No Interference between McDonough and Bell.*

As to the petition to reopen on the merits, the Commissioner holds that McDonough's original claim for the receiver having been rejected on reference to Bell's patent, and he submitting thereto and canceling the claim, and McDonough having been brought into the interference in consequence of the later applicants, so as to compel them to establish an earlier date of invention than himself, it follows inasmuch as there could have been no interference between McDonough and Bell alone, that when Gray and the other later applicants were defeated and taken out of the interference there could be left no contest between McDonough and Bell.

3. *Claims Voluntarily Canceled.*

Whether an applicant who has voluntarily eliminated his claims and apparently abandoned them should be permitted, after the invention has been publicly introduced and made commercially valuable, to return after 11 years and amend and claim an interference with a patent so long outstanding is a serious question, and the right to the relief should be most convincing.

4. *Petitions Denied—Insufficient Showing.*

Petitions denied because the showing is deemed insufficient to justify the Commissioner in setting aside former decisions and decrees, since he is fully convinced that another trial on the question of priority would result in another award in favor of Bell.

PETITIONS OF ELISHA GRAY AND JAMES W. MC DONOUGH TO AMEND AND TO REOPEN.

TELEPHONES.

A. G. Bell, patent No. 174,465, granted March 7, 1876, on application filed February 14, 1876.

A. G. Bell, patent No. 186,787, granted January 30, 1877, on application filed January 15, 1877.

Elisha Gray, applications Nos. 1, 2 and 3, filed October 29, 1877.

James W. McDonough, application filed April 10, 1876.

James J. Storrow and Roscoe Conkling for Bell.
Robert G. Ingersoll and Frank H. Hurd for McDonough.
M. B. Philipp and Casey Young for Gray.

Hall, *Commissioner*.

On the 26th of March, 1878, a series of interferences, lettered from A to M, were declared, and by an order of the commissioner dated March 6, 1879, case H was consolidated with case F and case K was merged in case I. By a stipulation between the parties thereto it was agreed that case No. 1 of a series of six interferences declared August 14, 1879, should be proceeded with and presented in connection with the lettered series. In September, 1880, case M was suspended by consent. Owing to the complex nature of the inventions and the variety of detail of events involved in the controversy, the issues were tried together upon the evidence taken by the respective parties, so far as it was relevant to the several issues.

The parties originally involved in one or more of the issues were A. G. Bell, James W. McDonough, T. A. Edison, E. Berliner, G. B. Richmond, E. Gray, A. E. Dolbear, A. G. Holcombe, C. E. Chinnock, C. A. Randall, F. Blake, J. H. Irwin, and G. M. Phelps. W. L. Voelker was made a party to case No. 1, November 3, 1879, and cases A and B December 29, 1879.

Prior to the date on which the cases were submitted to the examiner of interferences decisions had been rendered against Richmond (except as to case C), Holcombe, Randall, Phelps, Chinnock and Berliner, so that they were no longer parties to the controversy.

The evidence presented to the examiner of interferences was contained in five volumes: I. Testimony on behalf of Edison; II. Exhibits of Edison; III. Testimony on behalf of Voelker, Irwin, Gray, Dolbear, McDonough, Blake and Bell; IV. Vol. 1 of the record in the case of the Bell Telephone Company v. Dowd, comprising Bell's answers and proofs, introduced by stipulation; V. Vol. 2 of the record in the Dowd case, comprising exhibits, etc.

The taking of evidence was practically concluded in May, 1881. The case was argued before the examiner of interferences and fully submitted to him in October and November, 1881. He held the case under advisement until July 21, 1883, when he filed his decision, which covers 348 pages of closely printed matter. In cases A, B, C, E, F, I, J and L he awarded priority of invention to Bell; in cases D and No. 1 to Edison; and in case G to McDonough.

From this decision of the Examiner of Interferences Edison appealed to the Examiners-in-Chief in cases A, B, C, G, J and L. Voelker appealed in cases A and B and No. 1. Bell and Gray appealed in case G, and Irwin in case No. 1. This relieved the controversy of cases D, F and I, which remained finally disposed of by the decision of the Examiner of Interferences.

After having held the cases under advisement nearly a year, the Examiners-in-Chief, on October 23, 1884, rendered a decision affirming the decision of the Examiner of Interferences as to all of the issues except issue G, as to which they reversed him and awarded priority to Bell.

From this decision Voelker appealed to the Commissioner as to issues A and B, but Gray acquiesced therein and took no appeal; McDonough and Gray appealed as to issue G.

Pending the appeal before the commissioner, McDonough, on December 19, 1884, presented a motion

"to have the above-mentioned interference (G) re-opened in order that I may be permitted to introduce proof before the proper tribunal as to the operative character of the telephone transmitter shown in my application of April 10, 1876, involved herein, and for such other and further action in the premises as may be rendered necessary."

The grounds of the motion were that the examiners-in-chief had held that a make-and-break apparatus such as McDonough described was incapable of transmitting articulate speech; that this was at variance with the action of the primary examiner in declaring the interference, who must have found the apparatus to have been an operative one; and because, under the rules, the only method of raising the question of operativeness was by reference to the primary examiner. After full argument this motion was denied by the commissioner, on January 16, 1885.

On March 3, 1885, the commissioner filed his decision affirming the action of the examiners-in-chief as to all issues. This was a final award of priority in favor of Bell upon all the issues involved.

Nothing further appears to have been done by any of the parties in the interferences until December, 30, 1886, when there was received by the office the following petition of Gray:

"To Hon. M. V. Montgomery,
"*Commissioner of Patents:*

"Elisha Gray, one of the parties to the above stated proceedings, brings this his petition, to set aside the various orders, decisions and judgments heretofore made and rendered therein, and to reopen the same upon the following grounds, viz.:

I. "Upon the ground of newly discovered evidence, important and material in its character, and which would, as petitioner believes, have changed the various orders and judgments made and rendered in the progress of, and upon the final hearing of, said interference proceedings, if the same had been presented at the proper time to the officers of the Patent Office having them in charge and passing upon the matters and things pertaining thereto; and which evidence was not known to petitioner to exist; nor did he have any reason to suspect that it did, until long after the final decision in said interference proceedings was rendered against him, and in favor of A. G. Bell, upon nearly all the material issued therein involved; and therefore no laches can be imputed to him in not having earlier discovered and presented the same.

II. "The said newly discovered evidence will, as petitioner is informed and believes, establish the following facts, viz.: That on or about the first day of March, 1876, A. G. Bell, the successful party in said interference proceedings, went to the Patent Office, and, by undue and unlawful means and influences, procured full knowledge of the contents of, and drawings attached to, a certain caveat, accurately describing a speaking telephone, then recently (viz., on the fourteenth day of February, 1876) filed by petioner, and upon which caveat, and the invention therein set forth, and the apparatus therein described, were based the three (3) several applications for patent for a speaking telephone afterward filed by petitioner and involved in said above-mentioned interferences.

III. "By the knowledge thus obtained, in violation of law and the rights of petitioner, the said Bell was enabled to construct an apparatus, a few days afterward, by which he succeeded in transmitting articulate speech; and which apparatus, so constructed, in exact accordance with the drawings attached to, and the description and specification set out and contained in, petitioners's said caveat, he, the said Bell, subsequently claimed was the apparatus set out, described in and covered by an application which he had filed in the Patent Office on the said fourteenth day of February, 1876, purporting on its face to be an application for patent for 'An Improvement in Telegraphy,' but was never in any way claimed by the said A. G. Bell to be for a speaking telephone, nor recognized as such by any one else, until long after a patent had been issued thereon, on the seventh day of March, 1876, numbered 174,465, and which was involved in the aforesaid interference. While, in fact, no one of the devices or apparatuses set out and described in the said application never had previous thereto and never since, as petitioner is informed and believes, been made to transmit articulate speech.

IV. "It was not until after the time and the occurrences above narrated that the said Bell claimed he had invented the speaking telephone, or that he had mentioned described or claimed any such invention, or any device or apparatus constituting a part thereof, in said application filed on the aforesaid fourteenth day of February, styled an 'Improvement in Telegraphy;' and the fact is that the said Bell did not, in his said application, describe or claim any apparatus or device that could or can be made to operate as a variable-resistance telephone for the transmission of articulate speech; but by reason of having wrongfully and illegally obtained information as to the nature and contents of petitioner's aforesaid caveat, and of being thereby enabled to construct an apparatus therefore unknown to and never previously conceived of by him, that would transmit speech, and which apparatus he forthwith claimed as his own, the officers of the Patent Office were induced to adjudge him to be the first and original inventor of the speaking telephone, as against petitioner and others, because, as it was then believed, by reason of the above-recited fraudulent acts upon the part of the said Bell, he had first reduced the same to practice, though it was found and so reported by the examiner of interferences that he was not otherwise entitled to claim, or have awarded to him, priority over petitioner as to the said invention; and it was further found and so reported by said examiner of interferences, that petitioner lost whatever right he might have had secured under his said caveat to be adjudged the first and original inventor of said art of telephony as against said Bell, because of his own laches in not completing and reducing it to practice before the same was done by him, the said Bell.

V. "Petitioner further shows that by reason and in consequence of the aforesaid wrongful and fraudulent acts and doings upon the part of the said Bell, together with certain other irregular and illegal proceedings, hereafter to be set out, had and taken in the Patent Office concerning and in respect to his aforesaid caveat and the application of the said Bell, he, petitioner, was deceived and misled as to his real legal status in the Patent Office in respect to the speaking telephone, and as to his rights in relation thereto acquired by virtue of having filed his said caveat, and which rights were subsequently involved in the interferences aforesaid; and by being so deceived and misled, he failed and neglected to take such action and to obtain and present such proof in the beginning and during the progress of said interferences as he would otherwise have done, and which would, as he believes, have secured a judgment in his favor upon all the material issues involved therein, instead of being given in favor of said Bell; and among the said irregular, wrongful and illegal acts and doings, petitioner submits the following, to wit:

VI. "The aforesaid caveat of petitioner and application of said Bell being filed in the Patent Office on the same day, to wit, the fourteenth day of February, 1876, without any noting of the hour at which the respective filing occurred, the same was entitled to and should have been considered as a simultaneous act; and when said caveat and said application came for action before Z. F. Wilber, the primary examiner, to whom they were referred, he held and decided in accordance with the law and practice in that behalf, which had always theretofore prevailed in and governed the action of the Patent Office, that they were filed simultaneously, and that therefore said application should be suspended for ninety days, and that petitioner was entitled to notice of the pendency of said application, and to be also notified to complete the invention set out in his said caveat within the time prescribed by law; and the said examiner did, pursuant to law, give such notice to petitioner. But contrary to and without authority of law, he also notified said Bell of the pendency of petitioner's caveat informing him, at the same time, that it appeared to interfere with certain designated parts of his application. Upon the *ex-parte* application, however, of the said Bell, through his attorneys, Messrs. Pollok and Bailey, the aforesaid decision of the said Wilber was reversed, and it was then decided, without the taking of any competent and sufficient proof, and without notice to the petitioner, that his caveat was filed some hours later in the day than was the application of the said Bell. Whereupon, the notice given petitioner to complete his said invention was withdrawn; and soon thereafter, to wit, on the seventh day of March, 1876, a patent was issued, on the aforesaid application, to the said Bell, without models having been filed by him, as required by law, of the different devices or apparatus claimed to be set out and described therein, and without his ever having shown and demonstrated to the officers of the Patent Office, or to any one else, that the same were in any way fitted for or capable of performing the functions of a speaking telephone."

"By all of which, petitioner says the rules of the Patent Office were disregarded, the law violated, and great injustice done to him."

VII. "And petitioner further shows that said interferences should be reopened and set aside for further proceedings therein, because the same were wrongfully instituted, as aforesaid, and were not conducted in good faith, with a view to reach the real merits thereof; but were collusive and simulated in this:

"That before any proof had been taken in said interferences, or any substantial progress had been made in the same, those to whom the said Bell had previously transferred the ownership of the two patents involved, namely patents numbered 174, 465, and 186,787, acquired, or supposed they had acquired, by assignment, all the other patents and applications for patents (which were thought to possess any value) that had been put in interference with those of petitioner and of others; and among the patents and applications so acquired it was supposed by the aforesaid owners of the two above-mentioned patents of the said Bell, that the alleged interfering applications of petitioner were included; and petitioner being under *a misapprehension* in that regard, brought about by no act of his, supposed this to be true until long after the proceedings in said interferences were ended in the Patent Office.

VIII. "From the time these patents and applications were acquired, or supposed to have been acquired, as aforesaid, the interference proceedings in respect thereto, as between those representing the interest and claims of the said Bell and petitioner and certain other of the defendants, were mainly under the management and control of those who had acquired the aforesaid interest therein, and with the view of reaching such results as they desired, they paying, as petitioner is informed and believes, the counsel on both sides, as well as other necessary expenses.

IX. "And as a further and additional ground upon which petitioner submits that the various decisions made in the progress of said interferences should be set aside and the same reopened, is the following:

"That the patent of the said Bell, numbered 174,465 was adjudged by the officers of the Patent Office to be for a speaking telephone, and that it described an apparatus therefor, not upon any evidence presented to establish that fact, but because it had been so held and adjudicated in a consent decree taken and entered in a certain collusive suit, known as the 'Dowd' case, in which the same party, to wit, the American Bell Telephone Company, who had represented the interest of the said Bell in the aforesaid interferences was the complainant and one Peter A. Dowd was the nominal defendant; and in the progress of the same the parties thereto consolidated their interests, and a consent decree was entered in favor of the complainant, the American Bell Telephone Company, it paying the counsel fees on both sides of the case, together with all other costs and expenses of the same, as petitioner is informed and believes Under authority of this collusive adjudication, the officers of the Patent Office held that the aforesaid patent of the said Bell, numbered 174,465, should be put in interference with the applications of petitioner, though it was also held that said patent did not describe a speaking telephone, and that but for said adjudication it could not and would not have been put in interference as aforesaid.

X. "Petitioner asks that said interferences be reopened, upon the further ground that the officers of the Patent Office erred in putting the aforesaid patent of the said Bell in interference with the applications of petitioner as to the broad art of telephony, in this, that the said patent contains no description, specification, drawings or claim that would inform any one that it in any way relates to the art of transmitting articulate speech by any means pointed out or suggested therein; but it plainly appears upon the face thereof that it was intended alone for an improvement in telegraphy.

"And in this, that the apparatus which is described in said patent and shown in the drawings attached thereto is in no way like that set out in petitioner's application and shown in the drawings thereof, but is of entirely different construction, and operates, if it will operate at all for any purpose, upon a wholly different principle.

XI. "And petitioner further says that the officers of the Patent Office especially erred in awarding priority to said Bell in issue G of said interferences as against him, petitioner.

XII. "And, finally, petitioner moves the honorable commissioner to set aside said interferences, upon the further ground that the various orders, decisions and final judgment had and rendered therein are not supported by the evidence, nor warranted by the law applicable thereto.

XIII. "Wherefore, petitioner brings this his petition, with accompanying affidavits, proofs and exhibits, in support of the allegations therein set out and contained, and prays that the various orders, decisions and final judgment made and rendered in said interferences be set aside, and that the same by reopened, to the end that such other and further proceedings may be held in respect thereto as shall seem to the honorable commissioner to be just and lawful in that behalf.

"ELISHA GRAY.

"M. B. PHILIPP, *Attorney for Petitioner.*

"DISTRICT OF COLUMBIA,
"UNITED STATES OF AMERICA.

"Before me, A. S. Taylor, a notary public in and for said district, this day personally appeared Elisha Gray, who made oath that the statements contained in the foregoing petition are true, to the best of his knowledge, information and belief.

"Sworn to and subscribed before me this twenty-fourth day of December, A. D. 1886.

[SEAL] "A. S. TAYLOR, *Notary Public.*"

(*Endorsement.*)

"Office of Commissioner of Patents. Received December 30, 1886, petition of Elisha Gray to reopen the Telephone Interferences between himself, A. G. Bell and others.

"The petition is presented by Hon. Casey Young, with the statement that Mr. Philipp, counsel in the case, does not desire to have it acted upon until he shall hereafter present a formal motion asking therefor.

"M. V. MONTGOMERY, *Commissioner.*"

December 30, 1886.

No formal motion was subsequently presented by Gray asking for any action on the above petition, nor was any motion served by Gray upon Bell or other party of the filing thereof or that action would be asked. It was not until a general order of the commissioner was made applicable to all old cases pending in the Office to prevent delays and the prolongation of monopolies, that this petition was brought to the knowledge of the present commissioner, and under his direction it was set down for disposition on February, 1, 1888, and Bell and other parties notified.

February 18, 1887, an order was made by Commissioner Montgomery suspending action in Gray's case No. 3. Why this order was made or upon what reason, does not appear. It was made in case No. 3 as *ex-parte.*

February 23, 1887, Gray presented a proposed amendment in case No. 3, which was not entered in the case.

On April 4, 1887, Gray presented another amendment in case No. 3 which was not entered, but which is now before the commissioner as an *ex-parte* case. The amendment covers the metallic diaphragm.

March 2, 1887, McDonough filed in the interference case two petitions, as follows:

"I hereby move for an order for reopening the above-entitled interference, with leave to furnish proofs in regard to the operativeness of my teleloge as a speaking telephone; and respectfully present the following as the grounds for this motion:

I. "That the Commissioner of Patents, when the said interference was under argument on its merits, erred in receiving at the instance of the assignee of the contestant Bell, and in considering certain depositions, or what purported to be copies of certain depositions of Professors Brackett and Young, taken as a part of the evidence in the suit of the American Bell Telephone Company against the Overland Telephone Company, but forming no part of the interference record.

II. "The Commissioner of Patents erred in that he heard and decided the interference with the avowed determination, as expressed in his opinion, not to determine the issue adversely to the owners of the Bell patent; it being explicitly stated by him in such opinion that if he had become convinced that the board of examiners-in-chief were wrong in their judgment in awarding priority to Bell, he would have declined to reverse such judgment. His exact language was as follows:

"'If, on examination of the evidence in consideration of the arguments, I had become convinced that the finding and decision of the Examiners-in-Chief were erroneous, or if a serious doubt in that behalf had been raised in my mind I would have felt constrained to leave the case undecided, to be reheard by my successor.'

III. "The Commissioner of Patents erred in that instead of deciding the question of priority involved in the interference he did not either dissolve the interference (so far, at any rate, as Bell and myself were concerned), or else suspend it, and institute a special investigation as to the operative character of my 'teleloge' as a speaking telephone.

"In deciding the motion to reopen the interference, in order to permit me to adduce proof as to the operative character of my telephone, heard by the Commissioner of Patents, January 15, 1885, and refused by him in an opinion rendered on the following day, he said as follows:

"'If, on the hearing of this cause, I should ascertain that there is doubt about the operativeness of this device, and the question of priority should turn wholly on that point, and through inadvertance, mistake or surprise the evidence was not full and satisfactory, so as to enable me to reach a right conclusion without further evidence, such proceedings could be taken in that behalf as might be fit and proper to ascertain the truth. My opinion is that the case should proceed. If it occurs that further investigation shall become necessary, it is not only within the power but it would be the duty of the Commissioner to make such inquiry by means best calculated to ascertain the exact fact.'

"In view of this ground of denying the then motion to reopen it was error for the Commissioner subsequently in considering the interference on its merits to find (as it fully appears from an inspection of his opinion in the premises he did find) that the operativeness of my apparatus was a controlling factor in determining the question of priority, and at the same time not to take proper and effectual steps for the full investigation of that question, particularly in view of the fact that at the time of taking the testimony in the interference no issue was made between the parties as to the operativeness of my teleloge, neither Bell nor any other of the contestants having offered evidence to rebut the proved facts in regard to the actual transmission of speech by means of the instrument, or even theoretically in regard to its capability to transmit speech.

"The Commissioner erred specially in that, finding that the operativeness of my teleloge was vital to the determination of the question of priority, he allowed his mind to be influenced in the settlement of this fundamental question by the introduction into the case of matter taken from depositions that formed no part of the record, and as to which no opportunity was, or under the circumstances could be, afforded me to cross-examine the witnesses.

"That the depositions thus wrongfully introduced and considered had a controlling influence upon the Commissioner's decision appears from his opinion, in which he says:—

"I have considered the affidavits of Professors Young and Brackett *in connection with the evidence given by them in the case of the American Bell Telephone Company* v. *The Overland Telephone Company of New Jersey*' (being the depositions of which it is alleged that they were wrongfully introduced). 'Taking the evidence of these two scientists *as a whole*, I cannot find that they have demonstrated or that they unqualifiedly affirm the fact to be that a telephone using the make-and-break system, as contemplated by McDonough, will transmit articulate speech within the terms of the issue. It transpires in the cross-examination of those learned gentlemen' (in the depositions that form no part of the interference record, and in which I had no opportunity to cross-examine them), 'that they assume,' etc.

IV. "The Commissioner of Patents erred in that, in considering McDonough's invention of the teleloge, as described in his application of 1876, he failed to distinguish between the *actual invention* therein described and the *theory* therein presented in regard to the operation of the apparatus that constitutes the real invention.

V. "The Commissioner erred in holding that the underlying principle of my teleloge was that it should operate by a 'palpable' make-and-break system.

VI. "The Commissioner erred in not making award of priority as between me and Gray, it being upon the claim of the said Gray that the interference was based.

VII. The Commissioner erred in holding that my teleloge was inoperative to transmit speech.

VIII. "The Commissioner erred in holding (as in substance he did hold) that a telephone constructed on the make-and-break system will not talk, as is abundantly shown by the subsequent practice of the Patent Office in granting patents, special reference being made in this connection to the patent of Bonta, No. 333,816, January 5, 1886.

IX. "The Commissioner erred in awarding priority of invention to Bell, such decision being contrary to the law and the facts of the case, and contrary to sound practice.

"Wherefore, I respectfully petition the honorable the Commissioner of Patents for an order reopening the aforesaid interference, or for such other or such further relief in the premises as to your Honor may seem meet and proper, and may be just and equitable. "JAMES W. McDONOUGH.

"STATE OF NEW YORK,

"CITY AND COUNTY OF NEW YORK, ss.

"I, James W. McDonough, being duly sworn, depose and say that I am the person whose application for a patent for a teleloge (filed April 10, 1876) was involved in the interference above named; that I am advised and verily believe that an injustice has been done me by the decision in the said interference awarding priority to Mr. Bell; and that the above are good and sufficient reasons for reopening the interference.

"Subscribed and sworn to before me, this second day of March, 1887.

[SEAL] "ROBT. F. GAYLORD,
Notary Public (168), *N. Y. Co.*"

[PETITION OF ASSIGNEES.]

"Your petitioner, J. W. McDonough, a resident of the city and State of New York, and one of the parties to the above-stated interference proceedings, brings this petition, and respectfully asks that the aforesaid interference proceedings be set aside, and the various orders, decrees and judgments rendered therein be vacated and annulled upon the following grounds, viz.:

I. "Because the same were not conducted in good faith, as petitioner believes, and charges were fraudulent and collusive, and carried on with the purpose and intention of securing an award in favor of Alexander G. Bell upon all material issues therein involved.

II. "Because all of the orders, judgments and decrees taken and held in said proceedings, in so far as priority of invention as to the speaking telephone was awarded to Alexander G. Bell, were erroneous, and not supported by either the law or the facts applicable to the same.

III. "Because the proof does not show that Alexander G. Bell was the first and original inventor of the speaking telephone, or any material or necessary part thereof, but, on the contrary, the evidence shows that petitioner was himself first and original inventor as against the said Bell and the other parties to the proceedings.

"For the reasons above stated and others to be hereafter presented, petitioner prays that said interference proceedings may be reopened, and the different orders, judgments and decrees made and entered therein be vacated and annulled, and that all the issues therein involved be heard *de novo*.

"FRANK H. HURD,
"*Attorney for E. S. Stokes, and the North American Telephone Company, assignees of J. W. McDonough.*

"DISTRICT OF COLUMBIA, ss.

"Personally appeared before me, this second day of March A. D. 1887, Frank H. Hurd, who being duly sworn, says that the aforegoing petition is true, to the best of his knowledge and belief.

"FRANK H. HURD.

"Sworn and subscribed to before me,

[SEAL] "CHAS. S. BUNDY,
Notary Public, D. C."

It will be seen that the first of these motions seeks two kinds of relief: *first*, to have reopened the interferences and permit McDonough to take additional evidence as to operativeness; *second*, to have set aside the decision of Commissioner Butterworth, of March 3, 1885, on the merits, and to have a new trial granted. On March 17, 1887, this motion was submitted to Commissioner Montgomery, who, on March 29, 1887, filed a decision holding that as to the first branch of the motion he was concluded by Commissioner Butterworth's decision of January 16, 1885, which rendered the matter *res adjudicata*; but as to the second branch of the motion, the right to move to set aside the decision of Commissioner Butterworth, of March 3, 1885, on the merits of the interference, remained, unless it had been lost by laches. The decision concludes as follows:

"*First*. That McDonough has a right to be heard on the subject of vacating the award of priority made by Commissioner Butterworth, and such hearing is hereby fixed for the nineteenth day of April next, at twelve o'clock noon, at which time the petition filed on the 2nd instant by the assignee of McDonough, and which petition is not under consideration at present, will be called up for hearing.

"*Second*. I must decline to entertain that part of the present motion which is but a repetition of the one which was passed upon my predecessor."

This proceeding was conducted wholly independent of Gray's petition and proposed amendment, the former lying dormant, as before explained.

This motion of McDonough for a rehearing was not heard on April 19, but was continued from time to time until February 1, 1888. In the meantime Gray's amendment was a second time referred to the primary examiner for report. Bell was allowed to be heard, and on July 14, 1887, the examiner reported adversely to admitting the amendment. Subsequently Bell moved that the further hearing of Gray's motion to amend be postponed until after the Supreme Court should dispose of the telephone cases then pending before that tribunal. This motion was denied on November 23, 1887, and this decision advised Bell for the first time that Gray had filed a petition to reopen and set aside the interferences.

Gray's motion to amend was submitted before the Commissioner on December 1, 1887, and the argument of this motion resulted in causing the McDonough petitions and the Gray petition to be set down for disposition February 1, 1888. Gray made no request to have his petition so set down, nor did he do anything to have his petition called up for action. As previously stated, when the Commissioner ascertained that such a petition was on file, it was deemed that the public interest required that it should be disposed of without further delay. It was accordingly directed that notices issue fixing February 1, 1888, as the date of hearing. At that date parties appeared; the presentation of the McDonough petition began, and that of Gray's petition followed the conclusion of the former.

It has been deemed important to recall and set out this history of these proceedings, not only for the better understanding of the merits of questions involved, but because they characterize the conduct of the parties, to some extent, and to laches or diligence, which may affect to greater or less extent the merits.

The proposed amendment of Gray in case No. 3 has been disposed of separately as an *ex-parte* case. Reference to it here is due to its intimate relations with the matters now under consideration.

The McDonough and Gray petitions must be considered separately, but there are matters common to both which may be presented before entering upon them.

THE ISSUES.

The issues in these interferences are as follows:

A.

"The hereinbefore-described art of transmitting and reproducing at a distance, sonorous waves or vibrations of any description which consists in increasing and decreasing the strength of an electric current traversing a circuit in such a manner as to produce in said circuit a series of electrical waves or vibrations precisely corresponding in their intervals of succession and relative amplitudes to the sonorous waves, which are to be reproduced at the receiving station or stations, so that oral conversations or sounds of any description may be telegraphically transmitted."

In this interference was Gray's case No. 1, the subject-matter being that of his first claim, the Bell patent of March 7, 1876; and, among other application, those of Edison filed April 27, 1887, No. 130, Emile Berliner, filed June 4, 1877, and A. E. Dolbear, filed October 31, 1877.

B.

"The hereinbefore-described improvement in the art of transmitting vocal sounds or spoken words telegraphically, which consists in throwing upon the line, through the medium of a varying resistance, electric impulses corresponding to the vibrations of a diaphragm operated by the movements of the air produced by a spoken word."

In this interference was also Gray's case No. 1, the subject-matter being that of his second claim, the Bell patent of March 7, 1876; and, among other applications, those of Edison, filed April 27, 1877, No. 130, and Berliner, filed January 4, 1877.

C.

"*First*. The transmitter, consisting of the combination in an electric circuit of a diaphragm and a liquid or equivalent substance of high resistance, whereby the vibrations of the diaphragm cause variations in the resistance of the electric circuit, and consequently of the strength of current traversing said circuit.

"*Second*. In a telegraph-instrument operated by sound, the combination with the diaphragm of two or more electrodes placed in electrolytic liquid and operating to increase and decrease the resistance of the electric circuit by the movement derived from the diaphragm."

In this interference was Gray's case No. 2, the first part of the subjects-matter being that of his first claim, the Bell patent of

March 7, 1876; and, among other applications, that of Edison filed September 5, 1877, No. 144, the second part of this subject-matter being that of his first claim.

E.

"In an acoustic telegraph an armature-plate, the electro-magnet for the same, and a closed circuit passing from the helix of such electro-magnet to the source of undulatory electric energy."

In this interference was Gray's case No. 3, the Bell patent of March 7, 1876; and, among other applications, one of Edison filed December 18, 1877, No. 145, and that of Dolbear filed October 31, 1877.

F.

"A telephonic transmitter, consisting of a coil of wire, one or more magnets, and a disk or diaphragm, so arranged relative to each other that a motion of the diaphragm shall induce in the coil of wire an electro-motive force in virtue of the pressure of the magnet or magnets."

In this interference was Gray's case No. 1, the Bell patent of March 7, 1876; and, among other applications, that of Dolbear filed October 31, 1877.

G.

"A telephonic receiver consisting of the combination in an electric circuit of a magnet and a diaphragm supported and arranged in close proximity thereto whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality."

In this interference was Gray's case No. 3, the Bell patent of March 7, 1876; and, among other applications, that of Dolbear filed October 31, 1877, one of Edison filed December 24, 1877, No. 148, and one of James W. McDonough filed April 10, 1876.

H.

"The combination in one circuit of two or more coils of wire, two or more magnets, and two or more disks or diaphragms so arranged relatively to each other that if one of the disks or diaphragms be put in motion by the voice, by a current of air or otherwise, it shall induce a transient current of electricity in its associated coil, which current shall actuate the other disks or diaphragms in virtue of the coil and magnets associated with them."

In this interference was Gray's case No. 1, the Bell patent of March 7, 1876; and, among other applications, that of Dolbear filed October 31, 1877.

J.

"The combination, with an electro-magnet of an iron or steel diaphragm, secured to a resonant case for rendering audible acoustic vibrations."

In this interference was Gray's case No. 3, Bell's patent No. 186,787 of January 30, 1877, on application filed January 15, 1877; also applications of Edison and Dolbear.

The other issues are of no importance.

After the declaration of these interferences, a motion was made by Bell to consolidate them, which motion was denied by the commissioner because the motion was made *ex parte*, the other parties not being notified. (See Bell *v.* Gray, 15 O. G., 385.)

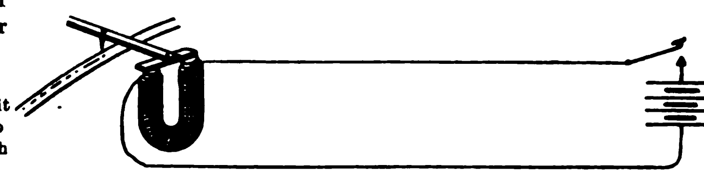
A second motion was made by Bell to reform the issues or consolidate them. This motion was resisted by both Gray and McDonough, and was denied by the commissioner on March 6, 1879. (See Bell *v.* Gray, 15 O. G., 776.) In this decision Commissioner Paine very clearly defined and construed the issues and that construction has been recognized in all subsequent decisions, both of the Office and the courts.

The Examiner of Interferences rendered a most elaborate and exhaustive decision in which he set forth the state of the art, settled what efforts had been made by the respective parties in the direction of the invention of the subjects matter of the several issues and the dates thereof; determined the facts relative to each, gave his construction to the issues, and awarded priority as hereinbefore stated. This decision, with the single exception of the construction of issue G, and consequent award to McDonough, has stood the test of all subsequent investigations, and, as a determination of the facts of the case, is, in my judgment, unassailable. No tribunal proceeding upon the evidence before the examiner of interferences would ever reach any other determination of facts.

THE STATE OF THE ART.

The decision of the Examiner of Interferences has not been officially published; I might perhaps be justified in setting forth his statement of the state of the art at the time the several parties to these interferences came into the Office, but it would doubtless take more space than would be best, and I shall therefore content myself with a brief statement.

Morse's patent for a method of telegraphy was issued in 1846 and reissued in 1848. Prior to that, various modes of telegraphing and making signs and signals by means of electricity had existed from as early a date as 1787. This had been accomplished by means of the movements of pith balls, electric sparks, etc., but the results of these methods were evanescent. The state of the art in this respect is concisely set forth in Morse's specifications. (See statement of the case in Morse *v.* O'Reilly, 15 How., 86.) But Morse invented a method by which stable or permanent signals or characters could be telegraphed. His method involved an electric circuit that could be closed and opened (make-and-break), and a piece of iron that could be magnetized and demagnetized. The ordinary Morse telegraph is well understood.



The elements required were a battery and circuits; a key to be manipulated with the hand; a piece of soft iron in the shape of a horseshoe-magnet around which passed the line-wire of the circuit, and an armature within the field of the magnet suspended on a spring. When the hand pressed upon the key and closed the circuit, the iron was magnetized and the armature was attracted to it, causing the pin to impress a dot or dash upon a scroll of paper, depending upon the length of time the circuit was closed. The click of the armature, as it came in contact with the magnet, also indicated the signals,—the dots and dashes,—and soon experienced operators became able to read the sounds of the instrument.

Here we have all the rudimentary parts from which have been evolved and developed the telephone. There are the transmitter, (the key), the electric circuit, and the receiver—the magnet and armature or plate (or disk). The transmitter operated upon the make-and-break principle, and yet it contained all the potential qualities of the modern microphone transmitter. When actually open no electric current or impulse traversed the circuit; but during the brief periods when the hand pressed the metallic electrodes constituting the keys together with greater or less force, the variable resistance of the microphone was actually executed, although without the knowledge of any one, for the secret possibility was unknown and unthought of. On the other hand, the armature suspended on the delicate spring unquestionably responded to and was capable of responding to not only the make-and-break variations, but also to the more delicate and imperceptible variations resulting from the variations of force by which the metallic electrodes of the keys were held together. If, instead of employing the hand to open and close the circuit, a toothed wheel had been adjusted so that the movement of each tooth should close and open the circuit, the armature would have faithfully responded. If the revolutions of the wheel were increased so that the circuit was opened and closed with a sufficient degree of speed, a tone would be produced at the transmitter and also at the receiver. But the tones would be those resulting from the mechanical clicking of the keys and the armature of the magnet. Still, it would also be true that the armature vibrating back and forth under the influence of the magnet would produce air-waves reproducing the tone, although they might be drowned or lost in those of the mechanical clicking of the armature.

Here we see the elements or modern discovery and invention. The transmitter was that of Reis—the make-and-break. The receiver was the magnet and the metallic diaphragm. In the Morse telegraph the armature responded to the mechanical opening and closing of the circuit; but it was potential of all that has succeeded. Was it only a new use of that armature when Reis, or Edison, or Bell, or Gray, or McDonough caused it to respond to the vibrations of tone? Was it a second new use

when Bell, or Gray, or McDonough caused it to respond, not only to pitch, but to quality—articulate speech?

The invention of the Morse telegraph stimulated investigation and invention in electricity. The idea of transmitting articulate speech took possession of inventive genius in Europe and America. Instead of making and breaking the circuit with the hand or a toothed wheel, it was proposed to introduce a mechanism so delicate that the makes and breaks could be effected by the sound-waves of the human voice. The delicate mechanism which in ancient times in the temple of Delphos was set into musical motion by the mere force of the rays of the morning sun was to be surpassed, not only in the delicacy and infinite variety of movement, but the results were to be transmitted in infinite directions and to infinite distances, and to constitute the invisible bridge between mind and mind. So that Morse has given to the world a receiver of the character described, and which possessed the capabilities that have since been discovered.

The Reis telephone had been given to the world. He introduced a transmitter constructed of electrodes which were opened and closed by the tone waves of the voice, or of a musical instrument operating on a delicate membrane called the "diaphragm." His receiver consisted of an iron rod attached to a sounding box, the rod being elongated and shortened under the influence of the rapidly-interruped electric current, as an iron rod is more slowly elongated or shortened by the effect of the heat.

As early as 1854 Bourseul had given to the world in publications suggestions as to the transmission of articulate speech, which contained descriptions of a receiver and transmitter. He said:

"The electric telegraph is based upon the following principle: An electric current passing through a metallic wire circulates through a coil around a soft piece of iron, which it converts into a magnet. The moment the current stops the piece of iron ceases to be a magnet. This magnet, which takes the name of electro-magnet, can thus in turn attract and then release a movable plate, which by its to-and-fro movement produces the conventional signals employed in telegraphy."

Then, after adding the mode in which speech is transmitted by the vibrations of the air, he continues:

"Suppose that a man speaks near a movable disk sufficiently flexible to lose none of the vibrations of the voice, that this disk alternately makes and breaks the connection with a battery; you may have at a distance another disk which will simultaneously execute the same vibrations."

In "The Wonders of Electricity," a publication translated from the French of J. Baile, published in 1872, there is found a further description of a receiver and transmitter. After adverting to the marvels accomplished in the transmission of thought, handwritings and drawings, and referring to the acoustic telegraph as disclosing a new principle or discovery, he says: "Already experiments have been made for this purpose," and he proceeds to describe an apparatus resembling that of Bourseul, with the addition of an electro-magnet for giving motion to the plate in the receiver. The transmitter contains a plate, which, at each vibration, touches a small point placed in front of it, and so throws an impulse of electricity on the line which shall cause the attraction of the second plate whose size and quality are identical with the former, causing it to perform the same number of vibrations per second and give forth a sound "which will have the same musical value as the first. If this be perfected a series of sounds, a tune, a spoken sentence and conversation" may be transmitted, but as yet it has not been accomplished.

Here is a complete description of a make-and-break telephone having a receiver consisting of an electro-magnet operating upon a metallic disk placed before it. There is no occasion here to consider or dwell upon the multiple or harmonic telegraphs invented by the various parties to these interferences. They all proceeded upon the make-and-break principle to be hereinafter considered. But the important fact to be noted is that at the date these several inventors entered upon the field of invention in respect of the transmission of speech, the electric circuit was old; the Reis transmitter was old; the metallic disk or armature attracted by a magnet was old. As to the receiver, unless there were invention in applying it to harmonic telegraphy over the Morse use of it in his telegraph, or in applying it to the reception of quality over and above both, then neither Bell, Gray, McDonough nor any one else could secure a patent for it broadly. It was as old as, if not older than, the Morse telegraph.

At the time these parties to the interference came into the Office it was old to produce variation in the strength or volume of the electric current by means of the variable resistance, whether effected upon the principle of the microphone or the liquid of high resistance. It is also proper to say that the telephone does not depend upon a diaphragm receiver, and that with a proper transmitter speech can be transmitted wholly without a diaphragm as an element in the receiver.

Thus when properly understood it will be seen that the telephone when invented consisted of elements which were all old, and that the invention consists in an adjustment and arrangement between these old parts by means of which a result never before reached was attained. It must also follow that not any of these old elements could be broadly claimed, but must necessarily be limited to their proper place and situation in that new arrangement and combination, and to their specific construction.

As the present petitions seek to have all the orders and decisions set aside, new evidence taken, and a rehearing upon the merits, it is necessary to a proper understanding that so much of the material portions of the decisions as relates to the claims of Bell, Gray, and McDonough be set out.

As to Bell, the Examiner of Interferences gave him as the date of his invention the date of the filing of his application. It was urged before him that Bell's application and patent No. 174,465 did not show the invention, and that he in fact had never conceived the invention of the telephone nor reduced it to practice until after his patent issued; but the Examiner of Interferences, while evidently inclining to this view, felt concluded by the decisions of Commissioner Paine and of the courts. He says:

"Upon the evidence presented it must be held that the subject-matter of this interference .... had not been invented, that is, demonstrated, by any of the parties to this interference prior to the filing of Bell's application, February 14, 1876; nor is it entirely clear that he had at that time any knowledge of a practical mode or mechanism for producing the results contemplated by the invention. But as the Office as well as the courts have determined that the patent contains a sufficient disclosure of the subject-matter in dispute, it must be held that the invention was made at least as early as the date on which he filed his application.

"Bell's claim does not, however, depend upon the application alone, for he was in fact and in law the first to disclose and publicly explain the principle, as well as the first to construct and use instruments not only designed and adapted to carry into effect that principle, but actually and successfully used for that purpose."

As to issue C, which covers the liquid transmitter, he says:

"While no such instruments are found described in Bell's patent, his proof as to 'Exhibit 41,' its description, use, and exhibition, are considered as amply sufficient to defeat the claims of Gray and Edison founded upon the facts appearing in the record, at the same time anticipating Richmond's record date of August 24, 1877."

As to Gray the examiner finds:

". . . He claims, however, that at this time (1867) he conceived the idea of constructing an instrument for transmitting tones 'similar in its general aspects to the instruments made at a later date.' As the character of these mental speculations cannot at this day be determined, and as they took no material form or expression until seven years later, they can no more be considered as affecting inventions subsequently developed, than can Bourseul's prophecy regarding the transmission of speech by electricity. He does not appear to have considered the matter further until the latter part of January or first part of February, 1874, when his attention was again accidentally called to the subject by what is known as the 'bath-tub experiment.' His nephew was engaged in taking shocks from an induction coil by connecting one end of the secondary coil to the zinc lining of a bath-tub and holding the other end in one hand Upon rubbing the zinc lining with the free hand to complete the circuit, Gray noticed that a sound proceeded from under the hand at the point of contact apparently of the same pitch and quality as that of the electrotome of the induction coil. His curiosity was aroused, and he at once tried the experiment himself, and was astonished to find that by rubbing hard and rapidly he could amplify the sound, and that by changing the rate of vibration of the electrotome a corresponding change was effected in the pitch of the sound under his hand. (Int. III, 387; Dowd, I, 123.)

"He says of this experiment that his attention was particularly attracted to the fact that 'the quality as well as pitch and loudness could be transmitted electrically through a telegraphic circuit and received upon a common or universal receiver (Dowd I, 123). Experiments were continued during February and March, using the same induction-coils and various receivers, among which was the exhibit Animal Tissue Violin Receiver, wherein a plate of metal is substituted for the strings, and by rubbing the hand across this plate the sounds of the electrotome were produced. It was during this period, according to Gray, that he conceived the idea of transmitting musical compositions and sounds of all kinds, including articulate speech (Int. III, 388); but, as would appear from

the record, his energies were directed exclusively to the transmission of musical tones and their utilization for telegraphic and other purposes, no attention being given to instruments for the *reception*, transmission and *reproduction* of articulate speech until along in February, 1876, and, although he claims to have had some conception of the *possibilities* late in the fall of 1875 (Int. III, 391; Dowd I, 125), he neither disclosed them to others nor clothed them in any fixed and positive form until he made the sketch for his caveat, February 11, 1876. Whatever may have been the inherent capacities of the instruments constructed in the interim, they were not designed for nor known to be capable of the transmission and reproduction of articulate speech (Dowd I, 389, 98-99; Int. III, 375-389), nor were his transmitters either intended or adapted for the reception of sounds, but were designed to create and originate the particular sounds to be conveyed. Both Gray and Goodridge were led to *believe* that the receivers used in the winter of 1874-5 were adapted to reproduce the sounds of the human voice, (Dowd I, 99-107-108-124), if they could be impressed upon and transmitted by the electric current, but they were totally unaware of any transmitter capable of performing this highly important and essential task, and it was not until Gray had witnessed the successful operation of Bell's telephone at the Centennial that possibility of using his receiver as a transmitter was suggested to his mind, as Gray frankly admits (Dowd I, 399). His idea of a transmitter—and it was merely an abstract idea, such as cannot under the law be regarded as a conception—is thus stated by him (Int. III, p. 388): 'During these experiments I observed that the quality of the sound made by the transmitter was faithfully reproduced in the receiver. This led me to the conclusion that it was only a question how to convert the aerial vibrations made by the production of any sound whatever into electrical vibrations of a similar character with respect to rate, amplitude, etc., to solve the problem of transmitting articulate speech. I was *convinced* that the receiver would reproduce articulate words inasmuch as it *seemed* to be capable of reproducing any form of vibration that I was *able* to transmit. I remember speaking of this to different ones about this time. I may have mentioned this before the first of April (1874), or it may have been a little while after. My impression is that I first mentioned it before. My conception then of an instrument for transmitting articulate speech was one of a complicated character, having a series of transmitting-points adapted to respond to all the tones of the human voice, somewhat similar to the apparatus referred to in my caveat of February 14th, 1876.' The description contained in said caveat is as follows:

"I contemplate, however, the use of a series of diaphragms in a common vocalizing-chamber, each diaphragm carrying an independent rod, and responding to a vibration of different rapidity and intensity, in which case contact-points mounted on other diaphragms may be employed."

"When called upon to explain the construction of the apparatus thus ambiguously outlined, Gray confesses that it was but a general idea not clearly defined in all its details, and was based upon a theory which has since proved to be false. (Dowd I, 135.) The instrument was never constructed by him.

"Thus, by tracing this original idea of a transmitter from its conception in 1874 to its mere mention in the caveat of 1876, we find that it amounts to nothing but an abstract speculation. Passing now to the form of transmitter described and illustrated in said caveat, and the application of October 29, 1877, we will endeavor to trace back its origin, premising, however, that Gray alone testifies as to these mental operations, for Goodridge, his assistant in all experiments during this period, when asked if Gray had ever described any instrument which he had devised for transmitting speech electrically by talking to the transmitter prior to the caveat, says (Int. III, 371:) 'I heard no description from Mr. Gray of any instrument which he had devised fully, but merely some idea or plan by which it could or might be done'; and his first definite knowledge of the transmitter illustrated in the said caveat was February 11, 1876, when the exhibit 'Speaking Telephone Caveat, original sketch,' was handed him for the purpose of having drawings made for a caveat. (Int. III, 336, 394.)

" . . . Gray seems to have been indebted to the so-called lovers' telegraph for suggestions as to the construction of an instrument for transmitting speech electrically. 'The observation in respect to the lovers' telegraph proved to my mind that the movements of a single point on the diaphragm corresponded accurately with the movements of the air produced by any spoken word or sound;' (Int. III, 397;) and it was after this observation in November or December, 1875 (Dowd I, 122), that he seems to have abandoned his preconceived ideas of multiple diaphragms (undoubtedly intended as analyzers, each diaphragm being tuned to and adapted for the transmission of a given note corresponding to its fundamental or normal rate of vibration), and to have fixed upon a single diaphragm as theoretically adapted for the reception of sound-waves and their conversion into corresponding electrical impulses. Gray thus describes the results of his observations on the 'lovers' telegraph' (Dowd I, 125); 'I saw that if I could reproduce electrically the same motions that were made mechanically at the centre of the diaphragm by speaking upon it, such electrical vibrations would be reproduced upon a common receiver in the same manner that musical tones were; and from the fact that the electrical vibrations were the same in respect to rate, amplitude and form or complexity, as the motions made in the air by uttering words or sounds, it followed that the receiving-diaphragm would be thrown into mechanical vibration or motion of a corresponding character, and consequently reproduce the same word or sound. The fact that the longitudinal movement (in water or other fluid of poor conducting quality) of a wire or some good conductor of electricity, with reference to another wire or metal conductor, produced variations in the resistance of an electric circuit proportional to the amplitude of movement, was old in the art of that time; so that the last link of knowledge necessary to solve the problem in my mind was furnished in the capabilities at the longitudinal vibrations of the string in the before-mentioned so-called lovers' telegraph.' But this knowledge does not seem to have been disclosed to others, nor to have been reduced to form until February 11, 1876, when the sketch for the caveat was made.

"The answer above quoted most satisfactorily confirms the conclusions reached regarding the incompleteness of his pre-conceived multiple diaphragm idea, for in it he acknowledges there was a defect or missing link, even in his theoretical transmitter, which was remedied or supplied by the 'lovers' telegraph' and the knowledge derived from observations made as to its operation. February 11, 1876, is, therefore, the earliest date that can be accorded Gray for the conception of his first instrument organized designedly for the transmission of articulate speech. . . .

" . . . He had already made and patented instruments capable of responding to varying impulses of electricity, but, instead of relying upon these for receivers, he contrived a new form of receiver, retaining only that part which was well known, long before his discovery, to be capable of responding to fluctuations in the current—*i.e*, an electro-magnet and armature, and to this applied the membrane diaphragm and vocalizing chamber of the lovers' telegraph.

"These circumstances lead to the conclusion, as before stated, that the invention of the art of transmitting and *reproducing* articulate speech, and the means therefor, was not contemporaneous with nor the natural outgrowth of the transmission and production of musical tones, as previously practiced by him; but it is to be regarded, under the law and upon the evidence adduced, as anterior to and derived from the lovers' telegraph, so called. . . .

" . . . It was during these experiments that he claims to have observed that the *quality* of the sound made by the transmitter was faithfully reproduced in the receiver, from which he drew the conclusion 'that it was only a question how to convert the aerial vibrations made by the production of any sound whatever into electrical vibrations of a similar character, with respect to rate, amplitude, etc., to solve the problem of transmitting speech' (Int. III, 388). He says, moreover, that he was 'convinced that the receiver would reproduce articulate words, inasmuch as it seemed to be capable of reproducing any *form* of vibration that I was able to *transmit*.'

"In the early history of the art the *possibility* of transmitting and reproducing speech by *imaginary* devices did not lack advocates, several of whom, prior to these alleged mental speculations of Gray, had approached much nearer in their prophecies and predictions than he ever claims to. The various descriptions of the Reis telephone evince a recognized capacity in the receiver to respond to such tones as were thrown upon the line by the transmitter; and various scientists have said it were possible *if* the means could be devised. Gray was, therefore, no nearer the solution of the problem when he recognized that the question was *how* to convert sound into electrical vibrations of a similar character than many who had preceded him. . . .

" . . . The history of his experiments, from the bath-tub experiment, in January or February, 1874, to the caveat sketch in February 1876, as narrated above, establishes beyond peradventure the character of the inventions upon which he was engaged, viz.; the electrical production of music and the multiple transmission of telegraphic messages. He neither sought nor contemplated the *transmission* and *reproduction* of sound as such; not a single transmitter was designed or adapted for converting sound-waves into corresponding electrical impulses; on the contrary, every tone or sound heard at the receiver, instead of being a reproduction, was a new creation, the product of a certain series of undulations induced in the current by the transmitter, and made manifest for the first time at the receiver. Tones accompanied the action of the transmitter while establishing these series of electrical vibrations or undulations, but they were merely incidental. He was aware of Reis's experiments, but evinced no disposition to follow in the same direction. He proceeded to develop a system of telegraphy wherein two or more transmitters were employed, each capable of setting up an arbitrary series of electrical impulses or vibrations in the line; the receivers at first were designed to respond to the tones resulting from these vibrations. (Dowd I, 100-1.) The knowledge possessed by him at that time led to the use of an electro-magnet for this purpose, for the researches of Page, Henry, and others, and his experiment in 1867, demonstrated the capacity of such an instrument to respond to electrical vibrations or impulses, and he himself acknowledges having observed this property in 1874, and that the armature or diaphragm, so called, was unnecessary (Int. III, 390); the duration of the vibrations of each transmitter was to be divided into longer and shorter periods representing the dot and dash of the Morse alphabet, and the sound of each, as produced by the receiver, was to be noted separately; (Dowd I, 99-100;) the resonant box, the wash-basin, and the tin cup were in all probability designed and used for the sole purpose of simplifying the sounds. At least there is no evidence to the contrary. In his first patent embodying the resonant-box magnet-receiver No. 166,095—he says, speaking of the secondary circuit: 'As the receiving electro-magnet is connected with the circuit it will be caused to vibrate, thus producing a tone of corresponding pitch, *the sound of which may be intensified* by the use of a hollow cylinder S of metal placed on the poles of the magnet. The 'diaphragm-box-magnet receiver' was regarded as a modification of the 'resonant-box magnet-receiver,' and was not made as a new form of receiver, but for use in testing the feasibility of transmitting tones over a long line. It was necessary that a receiver of some kind should be employed, and inasmuch as, at the time of said trial, 9th of Feb., 1875, one of the two resonant box magnet-receivers had been filed as a model in the Office and the other sent to New York, where it remained (Dowd I, 84-95), he had this diaphragm-box magnet-receiver made as substantially the same thing. The 'concave metallic diaphragm magnet-receiver' may therefore be regarded as the last of its type. Passing from this style of receiver, wherein two or more tones were produced, and, when employed telegraphically, required that the operater should disregard all but the one which he was to answer for (Dowd 4, 329), he devised a means for deadening all tones except the particular one corresponding to a given transmitter, and to this end he employed separate receivers, with sounding-boxes as analyzers, and this he also adopted for his musical receivers. The next

step forward was to provide the analyzing receivers with means for operating a local circuit, in which was included a Morse or other telegraphic receiver, when, and only when, the corresponding transmitter was in use.

"That this line of invention would ever have eventuated in the modern articulating-telephone no one can predict. The capacity of his receivers to respond to electrical undulations induced by a proper transmitter under the influence of sound-waves of any description, whether articulate, as in the modern telephone, or musical, as in the Reis telephone, was not capable of demonstration under the conditions in which they were used; it was a purely latent property, and would never have been discovered had the articulating transmitter not been invented. He does not appear to have even contemplated their use with a Reis transmitter or any other of its kind; hence his inventions were not engrafted upon the former as improvements.

"His mental speculations or anticipations of future possibilities for his instruments cannot be classed as inventions, nor even as conceptions of inventions, for they were neither reduced to definite form and proportions, nor experimented upon with a view to their development.

"The several receivers described were not designed or used for the *reproduction* of articulate speech or other sounds, but it is claimed that some of them, at least, possessed the inherent capacity of rendering audible sound-impressed currents; that this function was inseparable from the structure and was sufficiently demonstrated by the use made of the instruments. The devices mainly relied upon are the 'resonant box, concave metallic diaphragm, and diaphragm box magnet receiver.' These were used in 1874 and 1875 for rendering simple and complex tones, as produced by the musical transmitters heretofore described, and when so used included in a closed circuit.

"While it is satisfactorily established that they did perform the functions of musical receivers and operated satisfactorily to render audible certain electrical waves or undulations created by the transmitting-instruments, it is equally certain that such use was occasionally and experimentally only, and their use was ultimately abandoned and their place supplied by instruments of a different design.

"Aside from the fact that after a few trials they were laid aside and never utilized or applied in the same or modified form, it is extremely doubtful if the so-called diaphragms were intended to be responsive to the varying attractive force of the magnets, as from the testimony inferences alone can be drawn as to their actual operation. As one of the latter applicants, all doubts on this score must be resolved against Gray.

"The blacking box, the wash-basin, and tin cup were none of them employed primarily for producing the sound; that function was performed by the electro-magnet itself, as appears from the testimony and patent No. 166,095. Their purpose seems to have been the same as the resonant case and cover of the Reis receiver, *i. e.*, to increase the volume of the sound proceeding from the magnet. It is nowhere stated in evidence that any other purpose was had in view; hence it is fair to presume that if the diaphragms did, in fact, respond to the electrical variations, it was an unforeseen and unnoticed circumstance. And again, the magnet being, under the conditions of use, the source of sound, there was no necessity or opportunity for discriminating between the sounds which might have emanated from the diaphragm and those known to proceed from the core; hence the capacity of a diaphragm to respond to sound waves electrically transmitted could not and was not ascertained or taken advantage of.

"None of the witnesses refer to any observations made as to the capacity of the diaphragm to vibrate and thereby produce sound, irrespective of the audible effects produced by the magnets. There is every reason to believe that the cases were intended to act as reflectors or resonators, and that, in so far as the other functions of a vibrating diaphragm sensitive to sound-impressed currents was concerned, it was unknown, unappreciated, and would not have been mentioned as pertaining to the structure or use of these instruments were it not for the invention of the articulating-telephone, the introduction of which was the signal for the presentation of claims based upon devices which, so far at least as the sensitiveness of the diaphragm was concerned, had never been tested, the use of which in the system proposed had been discontinued, and the instruments virtually abandoned. . . .

". . . The system favored by Gray, and to which his attention seemed the most devoted, did not require or demand the sensitive diaphragm. Aside from what are termed the animal tissue receivers, we find him experimenting with universal receivers for a time, and ultimately putting them aside for individual responsive receivers. The first and third he embodied, in a variety of forms in patents, but the second found no place in these patents, except the resonant box receiver, which, as has been shown, was not alleged or claimed as containing a diaphragm.

"When he came to file his caveat, instead of nominating one of his old instruments for receiver he devised a new one, including a diaphragm stretched across a chamber, and carrying a piece of soft iron to act as an armature. This diaphragm becomes, in his application, a thin sheet of steel or iron, rigidly supported at its edges. Clearly, the use of these old instruments, in the manner, and for the purpose described in the application, was an afterthought, incident upon the introduction of the articulating telephone.

"Until then there was no suggestion as to their action, nor was the use to which they were put such as to develop or prove their capacity. As matters of evidence they furnished no fund of information from which the public or their projectors could derive any benefit. The so-called diaphragms were not regarded as the sound-producing medium; that was the accredited function of the magnet; but the devices of which they formed material portions were added to reinforce or deflect the tones, like a sounding-board and a sound-board respectively."

As to McDonough the examiner finds:

". . . This brings us down to the period when he claims to have first disclosed the invention to others. It will be well to consider the nature of the testimony we have been discussing, and its bearing upon the invention.

"In the first place, there is not the slightest proof as to the nature, structure or mode of operation of any instrument devised by him for the purpose of transmitting and reproducing articulate speech; nor does he even seem to have had a definite idea of such an instrument. There are but three circumstances that can be adduced in his favor: the experiment of 1867: the sketch of 1871, with its legend 'to send speech through wires by means of electricity,' and his conversation with Eastman in the spring of 1874, wherein he expressed his opinion that it might be possible to send speech over a wire, at the same time referring to the sketch of 1871 as being designed for that purpose. The question at once arises, does this constitute satisfactory proof of the conception of an instrument adapted for the transmission and reproduction of speech, or for any other purpose? The experiment of 1867 must be disregarded not only as uncorroborated and unwitnessed but as clearly abandoned. The sketch of 1871, as previously remarked, was made solely as a memoradum for recalling to mind fugitive ideas. Except for its legend, there is nothing to indicate in the slightest the purpose of the device represented; and the manner in which that object was to be attained is neither expressed in the illustration described to others, nor, so far as the evidence shows, was it understood or even devised by McDonough himself. . . .

"Apparently spurred on by the discussion with Eastman (1875) he entered upon what may be regarded as the first stage in the process of invention. He does not appear to have had such a knowledge of and familiarity with the art as it then existed as would enable him to judge of the correctness of his theory with any degree of certainty; he speculated upon possibilities, and was groping in the dark for the means of realizing his expectations.

"Let us assume that he had in contemplation an instrument for transmitting and reproducing articulate speech, wherein was to be embodied a diaphragm to receive the sound waves and another to reproduce them, with *some means*, unknown and unexplained, whereby the vibrations of one diaphragm were to set up corresponding vibrations in the other through the medium of electricity. If this constituted an invention, it was clearly anticipated by Du Moncel's description of a combination in every way as complete as any disclosed by McDonough up to this time. 'Imagine that you speak against a sensitive plate so flexible as to lose none of the vibrations produced by the voice, and that this plate makes and breaks successively the communication with the electric pile; you may have at any distance another plate, which will undergo in the same time the same vibrations.' (Prescott, 147.)

"But it is argued, McDonough had made and tested his receiver in 1867, and made drawings of a transmitter and receiver in 1871, and subsequently in 1875 made an instrument, whereas Bourseul never did. To this it is answered that the 1867 experiment, whatever it was, amounts to nothing, having been entirely and completely abandoned; while the 1871 sketch, standing, as it does, alone and unexplained, proves nothing whatever. A speaking telephone made according to Du Moncel's description has never, so far as we are advised, been successfully operated, and there are defects and omissions which, in the present advanced state of the art, make it apparent that it could not be made to work. But what can be said of McDonough's devices? He has made no record of his ideas, hence we cannot say they were either good or bad, for the simple reason that we do not know what they were. As to the receiver alleged to have been made in 1867, there is nothing to indicate its capacity even to receive and reproduce the impression made upon the current by a proper transmitter, had one existed; but, inasmuch as the transmission of articulate sounds by means of electricity had not been, to his knowledge, accomplished, the capacity of the receiver to respond thereto could not have been determined by him had the said receiver been in his possession and in daily use with the mechanical transmitter. This, then, was the status of McDonough's inventions when, in the latter part of May, 1875, he began the construction of his first instruments designed for the transmission and reproduction of articulate speech by means of electricity. (488.)

". . . As to the results produced, McDonough says: 'We could hear with this instrument perfect tunes and could distinguish the tone of the voice, but I do not remember of hearing any distinct words.' (492.) Whereas Eastman, who assisted, says: 'The results from these experiments, as heard at the other end, or in the receiver, was a variation of rattling sound and musical tones; (510;) and again: 'We made many experiments with this machine, and at times we could distinguish the tune that was sung. (*Ibid.*)

"Without apparently understanding the cause of his failure, or at least without any express purpose to depart from the general principles embodied in these first instruments, he constructed a new transmitter and receiver (493, 4, 5.) which he tested at a date not later than the 30 of June, 1875. (496.) Although McDonough fails to state the purpose of any changes effected in these new instruments, Eastman says he thought the diaphragms were too small (510), and that the needle was abandoned, because he could find no way to keep it from jumping; (511;) whereas, it would appear from his previous answers (q. 15, p. 510) that McDonough sought to facilitate the movement of the needle by putting in the glass tube; and the new transmitter, as at first constructed, did not provide a means for maintaining contact, but the necessity for some device for preventing the displacement of the contact-piece was suggested by the use of the instrument. (495.) The instrument made at this time is illustrated in McDonough Drawing No. 4, Transmitter Exhibit No. 3, and Receiver Exhibit No. 4, and is substantially identical in principle and mode of operation with that upon which the present application was based. (502.)

"He took the iron hoop, twelve inches in diameter (499), used in his 1867 experiment and had a duplicate made. Upon each of these hoops he fastened

parchment diaphragms, by first winding cotton cloth around the hoops, and then pasting the parchment to it. Near the centre of one of the diaphragms is pasted a piece of tinned iron, and mounted the hoop upon a base in front of the electro-magnet used in his previous experiment. This constituted the receiver.

"The other hoop he used in the transmitter. Near the centre of the diaphragm two pieces of thin German silver were pasted, about an inch and a half apart (499), with a wire attached to each. A bridge or arch-shaped piece of this German silver rested loosely upon the pieces of German silver on the diaphragm; the circuit was from one of the pieces, through the bridge to the other piece, thence through the coil of the receiver back to the battery.

"When these devices were first tested it was found that the bridge piece was shaken off from the contact pieces by the vibrations of the diaphragm; and to remedy this he sought to maintain the bridge piece in place by passing a thread through it and the diaphragm, tying a knot above the former, and one below the latter. He mentioned incidentally that they 'twisted the thread to tighten it' (495), referring to the bridge piece. With these instruments, McDonough says, 'we could distinguish tunes and some words distinctly.' (495.) He then substituted for the thread a screw-threaded pin, fastening it to the diaphragm by two nuts, one above and the other below, and placed another nut above the bridge piece.

"This constitutes the perfection of his invention, and it only remains to consider the nature of the results obtained therewith. . . .

". . . The results obtained are testified to as follows by McDonough: 'We obtained results as follows, viz., clearly-recognizable tunes and entire sentences of clearly understood words were transmitted through the instruments and heard at the receiver;' (496;) and when asked to specify the tunes or spoken words, he says: 'To my knowledge, the tunes were "Swanee River," "Muffin Man," "Shoo Fly," and some others. The words which impressed themselves upon me more particularly were, "Way Down Upon the Swanee Ribber, far, far away," which I heard consecutively and clearly, noticing the elision at the beginning of the word "way," and the change of "v" to "b" in the word "river." The words of other tunes were distinct when the instruments were properly regulated. I myself could distinguish peculiarities of voice in those speaking or singing. (497).

EASTMAN:

"I assisted Mr. McDonough in operating the machine whenever I had time, and we were home together generally every evening, and I guess we exhausted all the songs we ever heard. I can give you the names of a few of them; others I do not remember. They were 'Swanee River,' 'Down in a Coal Mine,' 'Old Zip Coon,' and others that I have forgotten. I heard many of the words of these songs; exactly which words I can't remember. I also heard Mr. McDonough say 'Halloo, Frank,' and other words that I can't remember now." (512.)

WILSEY, McDonough's stepfather:

"It was in the latter part of June, the exact date I can't recollect, 1875, at 72 Warren Avenue, Chicago, I asked Mr. McDonough what results he was getting. He told me he was pretty well satisfied. I requested him to let me listen, in order to hear whether I could hear anything or not. I listened at it. At first I heard nothing. I concluded that I was a little too far from the machine. By getting very close to it I could hear singing; I was able to determine what tune he was singing. I also was enabled to catch now and then a word; that is all." (522.)

J. E. McDonough, applicant's brother:

"It was at 72 Warren Avenue, in the latter part of June or near the first of July, 1875. I was called to listen by my brother one evening while my mother was singing in the parlor of the house, and I heard the singing; and, slapping my brother on the back, and saying, 'By George, Jimmie! you've got it after all' (524), I heard "Down Come Uncle and Aunt, Down Come Sister Caturah." That's about all I can recollect at the time of hearing.' (525.) The words referred to above were the words of a song he had often heard his mother sing. (526.)

The above are the only parties who testify of their own knowledge as to the working of the device. In addition to this, however, there is the evidence of three parties: Jeffery (527), Cobb (529), and Wilkins (532), to the effect that in 1875 McDonough incidentally stated to them he had an instrument with which he could send speech through wires, by means of electricity. . . .

"With respect to the construction and mode of operation of the several devices before referred to, evidence of two kinds is presented, and from this and the surrounding circumstances we are called upon to determine, as best we may, the nature and extent of McDonough's invention; for with the filing of his application his work as an inventor in this line came to a standstill.

"The two kinds of evidence referred to are the testimony of witnesses as to transactions occurring a number of years previous, and the description of the apparatus as contained in the application. With respect to the first of these it would seem, upon a careful examination thereof, to be insufficient to establish beyond doubt or question the successful reduction to practice of an articulating telephone, whatever else it may prove. Not a single witness describes, nor does it appear that he was conversant with, the conditions necessary to render the instruments capable of transmitting and reproducing articulate speech. It is not pretended that, prior to the last of June, 1875, any instrument had reproduced a single articulate sound; and this was due, it would seem, to the fact that the transmitter broke the circuit instead of maintaining a constant control over it. Without designing, so far as the record shows, to depart from the principles underlying previous constructions, he made an instrument such as is embodied in his application, obviously capable of operating in the same manner as those that preceded it, and with it obtained the results stated. Conversation was not carried on with it, but tunes were recognized, together with some words of the tune. A sound approximating to a familiar tune naturally suggests to the mind the words; it is frequently a mental deception, as observation teaches. That his experiments amounted to more than this, has not been satisfactorily proved. He may have advanced a little beyond Reis, but it is not certain.

"Not having fully realized his expectations, he attempted to improve not alone the loudness, as he would have us understand, but the distinctness also (518;) in this he failed. Fearful lest others should outstrip him in the accomplishment of that for which he was seeking, but had not found, he concluded to file an application for a patent.

"This application, then, must be presumed to contain the best explanation of his invention that he could furnish to the public; it forms the standard with which his invention must be compared and measured. Further progress was abandoned, the instruments neglected or destroyed, and, except as described in said application, not a single person, including himself, knew how to construct and operate the devices for the accomplishment of the end in view. Even if accidentally and without knowing how to repeat the operation he had used the devices in such a manner as to produce the result aimed at, he had not made the invention, for he could not repeat the effects. He is not entitled to a patent for possible combinations, but for such only as he has devised and can and does instruct the public in the use of. The mere allegation that a described combination will produce a certain result when in fact it will not, does not render him entitled to exclude others from using the same elements in a different relation for producing that result. Such changes amount to independent inventions. What others may succeed in doing with the instrumentalities he had constructed by establi hing a relation of the parts unknown to him does not inure to his benefit nor entitle him to claim such invention as his own.

"The application, which we will now consider, was filed by an attorney who undoubtedly received information for the preparation of the drawings and specifications directly or indirectly from McDonough himself. He is not produced, however; hence the application, stands alone as representing what he had accomplished, and it cannot be departed from; and, if it could, there is certainly nothing in the testimony to warrant the conclusion that, without apparent reason or purpose, he, either ignorantly or designedly, described his invention other than as he knew it. The instrument is denominated a teleloge, and, as we find no evidence of its having been so termed before, it is fair to presume that the word was coined at the time and for the purpose of the application. . . .

". . . Then follows a description of the apparatus made the last of June, 1875, the bridge-piece being referred to as the *circuit-breaker*, and is thus described: 'D is the circuit-breaker, which consists of an arch-shaped piece of metal *loosely* secured at its centre upon the bolt D, and is bent upward at e ch end, and from the membrane A, as shown in fig 3, so as to form independent V-shaped points adapted to rest upon the respective plates C C. The circuit breaker D is so fitted upon the bolt D as to admit of a free and easy ascending and descending movement, *the limit of its ascending movement being determined by its contact with the nut E on the bolt, and the descending movement being limited by its contact with the plates C C*'. . . .

". . . There cannot be the shadow of a doubt but that he claimed to have invented an instrument which should operate to transmit articulate speech by opening and closing, or, as he says, 'breaking and closing,' an electric circuit. It is the judgment of all the experts examined in this case, as well as of the Office, that articulate speech cannot be transmitted by such an instrument. Had a patent been granted upon this application as it stands it would undoubtedly be void as for an inoperative device.

"As opposed to this proposition, what do we find tending to establish the contrary? Only the testimony of three or four witnesses that they recognized the words of some familiar tunes, and the allegation contained in the application that a device constructed as described will transmit and reproduce articulate speech. This, it is submitted, is not sufficient proof of the fact; the only inference that can be drawn from the record is that the witnesses are either mistaken, or he operated the device in a manner different from that set forth in his application, and unknown to him.

"But these are not the only circumstances from which such a conclusion can be drawn. He describes in his application an alternative form of transmitter, which must be presumed to operate upon the same principle and with the same results as the one illustrated. *It is the instrument made in May*, 1875, with which they could 'recognize tunes *but no words*,' and is thus described: 'I do not limit myself to the construction and arrangement of the circuit-breaker D,' as shown and described, 'as other means may be employed, as for example, only one of the plates C may be attached to the membrane and the other made either in the form of a plate or *needle* and attached directly to the connecting wire, and adjusted to rest upon the plate *so as to break the connection by the vibration of the membrane, which will accomplish the same result*. . . .'

". . . There is but one more circumstance to be noted, and the history of McDonough's invention will be completed. Interferences A to L were declared March 26, 1878, at which time the applications were open to inspection by the several contestants. McDonough was included in G alone, but from the complex nature of the several cases they were treated substantially as one case, and he undoubtedly knew of the other issues involved, and knowledge is brought home to him in the matter of the decision of the commissioner, published in the *Official Gazette* of May 13, 1879, he being a party thereto. In a communication addressed to the Office and filed August 23, 1879, he makes the following inquiry: 'Having fully described in my application filed April 10, 1876, a *speaking* telephone, am I not properly concerned in the case of Interference A?' to which the Examiner of interferences replied, under date of August 28, 'that the judgment of the Office was that he could not be a party to case A. If he thinks that judgment wrong, his proper remedy is to move (by regular motion) to be made a party thereto.'

"Had the Office regarded McDonough's mode of operation as the same as that of the contestants in case A, his application would have been included therein: but as it purported upon its face to be for a different method, and the Office not

being in a position at that time, for want of sufficient information on the subject, as yet in its infancy, it was not rejected as inoperative for the transmission of articulate speech, but the interference was declared as to the receiver alone."

As to issue G the examiner of interferences finds :

"For the reasons heretofore stated in construing the issues, this interference is held to embrace a receiver containing an electro-magnet and a diaphragm supported and arranged in close proximity thereto, *and adapted to respond to variations in the electric current passing through the coils of the magnet, when used in connection or combination with a transmitter adapted to create sound producing fluctuations in the electric current, whether said electrical variations, waves, pulsations or undulations represent or are derived from sound waves or mechanical vibrations.* . . .

". . . McDonough's application was filed April 10, 1876, shortly after the grant of Bell's patent, and before his lecture of May 10, 1876, or the introduction and use of the articulating telephone ; so that his efforts in this direction may be regarded as entirely independent of and uninfluenced by Bell's disclosures and inventions.

"It is evident that McDonough represented and claimed for his transmitter more than it had been proved competent to perform, but it is equally clear that as to his receiver it was shown to be capable of carrying into execution this invention and of responding to such electrical waves or pulsations as he was able to transmit. The Office held his instruments to be modifications or variations of the Reis Legat telephone, and with that understanding included him as a party to this interference, thereby admitting that his receiver as described and shown embodied the invention, and that it differed from or was an improvement upon the Reis-Legat receiver.

"Now, it is satisfactorily proved that McDonough made and used substantially the receiver shown in his application, and in connection or combination with substantially the same form or character of transmitter there shown, as early, at least, as May, 1875, for transmitting and reproducing musical tones, and that he was reasonably diligent in the prosecution of his experiments, which eventuated, not in a successful articulating telephone, but in the instruments contained in his application.

"There is some evidence tending to show an earlier conception of this invention, but he cannot derive any benefit therefrom because of his unreasonable delay and want of diligence prior to May, 1875, in carrying into practice his designs.

"It is perfectly evident that, under the law, McDonough cannot be deprived of his right to a patent for such matters as he has shown to have actually invented, diligently prosecuted, and for which he has filed an application (and it matters not that the advance or improvement was but slight and restricted in its application), unless it shall appear that, prior to the date of completion of his invention, another had perfected or had conceived and was diligently prosecuting to completion the same invention.

"Taking, therefore, May, 1875, as the date of McDonough's invention of the receiver in issue, it only remains to be considered whether Bell has proved prior conception, for he does not pretend to have constructed such a receiver prior to July, 1875.

"Upon the evidence submitted it is impossible to find that he had conceived, much less disclosed, the invention in issue in this case. In his disclosures to Blake in October, 1874, no suggestion is made of any change in his system, as illustrated in the 'harp instrument,' except as to the means for transmitting sound vibrations ; and from that time until June, 1875, no further disclosures or experiments were made ; and when the matter was taken up in June, 1875, and the first tangible expression given to his ideas, he used a reed receiver.

"Upon this count, as defined and explained, J. W. McDonough is awarded priority of invention."

Upon all the other issues now involved priority was awarded to Bell, as already stated.

THE DECISION OF THE EXAMINERS-IN-CHIEF.

Gray did not appeal from the decision of the Examiner of Interferences as to any of the issues, except issue G, but acquiesced. Voelker and Edison did appeal. Bell, Gray and Edison appealed as to issue G. It is unnecessary to set out the decision of the Examiners-in-Chief, excepting in so far as it relates to issue G. As to the other issues, it is in accord both as to the construction of the issues and the conclusions of fact with the decision of the Examiner of Interferences, whose decision was affirmed except as to issue G.

As to Bell the Examiners-in-Chief said :

"Bell is the only one of the contestants having patents. Of these, his first, granted March 7, 1876, has been vigorously attacked upon the ground that it does not disclose the invention in controversy, but this question has already been determined by the Office when the patent was granted, when the interference was declared, and when, in Bell *v.* Gray (C. D., 1879, 42), the Commissioner defined the various issues ; and by the courts, in American Bell Telephone Company *v.* Spencer (8 Fed. Rep., 509) ; and Same *v.* Dolbear (15 *ib.*, 448). It is not now therefore to be considered by this tribunal as open."

"Neither will it be necessary for Bell to prove reduction to practice. Having a patent, the law presumes that his invention was complete when he filed his application describing it."

They cite in support of the last proposition the following authorities :

Wheeler *v.* Chenowith, C. D., 1869, 48.
Hammond *v.* Laird, C. D., 1875, 23.
Potter *v.* Holland, 1 Fish, 382.
Cahoon *v.* Ring, *ib.* 397.
Busha *v.* Phelps, C. D., 1876, 116.
Huntly *v.* Smith, C. D., 1880, 182.
Starr *v.* Farmer, C. D., 1883, 34.
S. C., Secretary of Interior's Decisions, C. D., 1883, 116.

The Examiners-in-Chief then cite numerous authorities to show that in an issue between an applicant and a patentee the burden of proof is upon the former, and the evidence to sustain priority over the patentee must show an earlier conception followed by diligence toward reduction to practice, or an actual reduction to practice ; and such evidence must be of the clearest and most satisfactory character. In their decision the Examiners-in-Chief say :

"The issue is in substantially the language of Gray's claim, and its exact scope and meaning have been made the subject of such controversy. The controversy has arisen from the fact that the issue states the combination as a telephone receiver, and its object, the reproduction of both the pitch and quality of the transmitted sound.

"On this account it is contended on the part of Bell that there must be read into the claim a device for transmitting quality, that is, an articulating transmitter, and on the part of Gray that it is sufficient if the transmitter transmit 'rythmical vibrations of any and every description, including the tones of the human voice and articulate speech.' McDonough, it seems, agrees with Bell.

"The Examiner, reasoning from the premise that while the other parties show articulating transmitters, neither McDonough nor Edison does, and Gray contemplates the transmission of sounds produced either by mechanism or the human voice, reaches the conclusion that the issue embraces any receiver consisting of the elements named, whether used in connection with an articulating or other transmitter, and whether it reproduces quality or not.

"'The construction given the claim,' [he says], 'the combination of the electromagnet, the diaphram, and an electric circuit over which sound-producing currents are transmitted, is in harmony not only with the express declaration of the applicant upon whose demand for a patent these proceedings were instituted, but also with the action of the Office in including the applications of Edison (No. 148) and McDonough.

"'If an articulating transmitter forms an essential element of Gray's claim, these applications could not properly have been joined in the interference, for neither shows or describes such an invention.'

"It is, however, necessary for the determination of the issue that some kind of transmitting instrument be used to throw sounds upon the line. The terms of the issue require this, and also that the quality of such sounds shall be reproduced. Hence, if it be possible, some means must be adopted to bring all the parties within these terms, but to do this the manifest requirements of the issue should not be disregarded.

"It is held by the examiner, as above quoted, that a limitation of the issue to an articulating transmitter would do violence to the direct statement of the applicant whose claim forms the basis of this issue, but this does not necessarily follow. Upon examination of Gray's specification it appears that he states the object of his invention to be 'to provide an apparatus capable of accurately reproducing in an electric circuit not only the different tones but the pitch and quality of sounds, whether produced by mechanism or the vocal organs.' In fig. 2 he shows his receiver in connection with a series of vibrating reeds, each transmitting a tone of different pitch, which may be operated simultaneously or successively. It is not intended to transmit quality with this apparatus, but the statement is simply that the *tones* are transmitted and reproduced. When, however, the arrangement shown in fig. 3 is described, in which receiver and transmitter are alike, it is expressly stated that 'articulate words spoken in one instrument will be accurately reproduced in the other, both as to pitch and quality as well as *tone*.' It is upon this latter description that the claim is based, for after stating the elements of the combination he uses substantially the language employed in describing fig. 3, whereby sound thrown upon the line may be reproduced accurately as to tone, pitch and quality.

"It thus appears that not only is no violence done to Gray's statement by such a limitation of his claim, but that a fair inference to be drawn from considering it in connection with his specification is that he himself so intended to limit it, else why insert so carefully the word 'quality'? The fact that his receiver is also capable of reproducing other sounds should not be decisive in construing the issue. The greater includes the less. If a given apparatus transmit and reproduce quality, it will likewise pitch and tone, and the issue is not who first constructed a device to reproduce these, but these in conjunction with quality.

"As to Edison, it is true that his application No. 148 does not show or describe an articulating transmitter, and that he, therefore, does not transmit quality ; neither does McDonough. It is, however, none the less true that Edison's application No. 145 does not disclose such a transmitter, but the commissioner, when these issues came before him for construction and reformation, held that issue E, which includes and is, in fact, based upon Edison's claim in No. 145, embraces a devise which was a necessary part of the means for carrying out the method involved in issue A, *i. e.*, the transmission of articulate speech. Following his lead, this tribunal made an articulating transmitter an element of that issue, and such a course is equally proper here, for this issue was similarly construed by the commissioner in that same decision.

"In considering it he says:

"'It is true that this receiving device is but the transmitting device of "Interference F" reversed, but the fact that the device as used in "interfence G" would enable an undulatory current of electricity to reproduce, at the point of delivery, the same sound vibrations which had been caused *by articulate speech* at the starting point, was not enough to suggest to the skilled workman or electrician that the same device would, if reversed, enable the sound vibrations caused *by the spoken word* to cause such variations of the electric current as to reproduce at a remote point of the circuit the same sound vibrations.'

"Language could not more plainly indicate than this the guiding principle of this entire proceeding, and it was not only the intent of the Office that the invention of the speaking telephone should be tried here, but it was also the intent of the parties. Their testimony has all been directed to this end, and with the exception of Gray, they are all still insisting that they invented not only the art but the apparatus. At the beginning of this controversy Gray made the same contention and filed simultaneously three applications: one for the method, one for the transmitter and one for the receiver. That he has withdrawn f om the contest, except as to this issue, does not entitle him to have one of these applications used as a basis for an interpretation which neither he nor the other parties originally intended. Bearing this intent in mind, then, and the further fact that no other one of the issues will permit it, where else shall the question of priority as to the receiver be determined if not under this issue?

"It was pertinently remarked by counsel for McDonough, that without an articulating transmitter the receiver of this issue could not practically be tested, and its capability of reproducing indiscriminately the quality of any and all sounds could not therefore be known. It may as pertinently be ask d how, then, can the question of priority be decided upon an issue whose terms require the transmission of quality unless the only instrument which has this capacity be included, *i. e.*, an articulating transmitter?

"To sum up briefly, it appears that this interference was sought by the parties to determine who invented the speaking telephone, the art and apparatus for carrying it out; and the declaration was made by the Primary Examiner for the same purpose. The Commissioner, upon a proceeding to reform the issues, recognized and confirmed this, the parties accepted it, and the testimony was taken with it in view. Gray formerly insisted, and Edison and McDonough still insist, that not only the art is of their invention, but the apparatus also, and it is only by including an articulating transmitter in this issue that the question of priority as to the receiv r can properly be determined.

"If the construction of the issue given by the the Examiner of Interference is to prevail, and priority be awarded to a party who had no articulating transmitter, it would result that an experimenter who had tried to transmit speech and failed, or one who had never tried, should so dominate the art that an inventor who had worked out the idea, patented his process of carrying it out, introduced it to the public and put it into extensive use, could not practice the art which he had created without being tributary to his unsuccessful rival. . . .

". . . Stated more specifically his (Gray's) proposition is :—

"'That as certain devices he mentions are not only capable of acting as receivers of articulate speech, but when properly organized as to their circuit connections will operate both as receivers and transmitters of articulate speech, . . . it makes no difference whether Gray knew or not that his instruments possessed this quality so long as they did possess it. Gray knew that his receivers would reproduce the quality of sounds transmitted through the line, and he believed that if he could transmit articulate speech it would probably be reproduced, but he at that time did not have the conception of such a transmitter.'

"That is, indeed, a shadowy theory upon which to rest his case, and the most conclusive answer to it is that of counsel for McDonough, before quoted, that he could not know his receiver would reproduce speech unless he was able to test it, and this could only be done by a speech transmitter. If he did not know this, how could he impart the knowledge to the public, and how obtain a patent?

"It is a prerequisite to the grant of a patent that it shall convey to the public the knowledge necessary to enable it to practice the invention, and it is just here that Bell and Gray differ. If Gray had obtained a patent for his instruments which he now says can transmit and reproduce speech, the public would not have been in any manner enlightened as to this art. He stands in an entirely different light from Bell, and the decision of Mr. Justice Lowell, in American Bell Telephone Company *v.* Spencer, *infra*, does not help him. It was not held in that case that it was enough for a person to have constructed an apparatus capable of doing a certain thing although he did not know it. Another and a controlling element entered into the decision, that a mode of doing this thing had been pointed out, and that the apparatus operated after this mode.

"'There is some evidence,' say the court, 'that Bell's experiments with the instrument described in fig. 7 before he took out his patent were not entirely successful: but this is now immaterial, for it is proved that the instrument will do the work, whether the inventor knew it or not, *and in the mode pointed out by the specifications*.'

"Gray had not only not pointed out how his receiver could reproduce speech, but he did not know himself until taught by Bell's patent.

"In this view of the case it will not be necessary to look into Gray's evidence, for it is admitted that he had never transmitted speech before the date of Bell's patent or application, and in the view we take of this issue it is immaterial when the devices upon which he now relies were constructed.

"The case of McDonough is somewhat similar to Gray's, though with this important difference, that he still insists that he is the inventor of the speaking telephone. His case, as stated by his counsel, is as follows:

"'We submit, therefore, that Mr. McDonough was the original and first inventor, because he had in 1867 practically used the magnet and diaphragm in combination for a receiver; had in 1871 conceived of the use of said combination for articulate speech; had reduced the same to a drawing, and in April, 1874, attempted to embody the same; being prevented by sickness he went to Europe; returning in the fall of 1874, he began in April, 1875, again to put his receiving apparatus together, and combined and used it with a transmitter in May, 1875, and applied for his patent April 10, 1876.

"All these acts of McDonough may be admitted, and yet priority cannot be awarded to him unless he can be shown to have had an articulating transmitter Upon this depends his entire case, and it becomes important to determine what he really had."

The history of McDonough's efforts and devices is then set out, following a line similar to that of the Examiner of Interferences. In conclusion the Examiners-in-Chief add :

"Upon the whole, McDonough's proofs cannot be held to be sufficient to overcome Bell's record dates. We have seen that a party contesting the right of a patentee must show completed and perfected apparatus. That McDonough did not have this is clear. Had a patent been granted to him for it as described in his application or as experimented with in June, 1875, the public would have been no wiser than before. It still would have been ignorant of the method and apparatus for speech transmission, for no instrument working upon its principle of making and breaking contact can accomplish that result. In this respect McDonough gave no more to the world than Reis. As was said of Reis, by Mr. Justice Lowell, in American Bell Telephone Company *v.* Spencer, above, a century of McDonough would never have produced a speaking telephone."

GRAY'S CASE.

As noticed several times, Gray acquiesced in the decision of the Examiner of Interferences as to all the issues except G.

It is important to understand why he pursued this course. This decision was rendered July 21, 1883. His present petition was not filed until December 30, 1886, three years and five months after the decision. Even then the petition was filed with a request that it should not be acted upon until further motion was made, and no notice of its filing was served upon the adverse parties. It is well settled that a petition filed and presented under such circumstances is of no avail for any purpose whatever. It performs no function. In the mean time, rights of other parties are accruing or vesting from lapse of time, statutes of limitation run, etc. It is only from December 1, 1887, that this petition can be justly said to have been filed, the date at which the Commissioner directed all matters relating to these interference cases to be set down for disposition.

Why, therefore, did Gray acquiesce in the decision and wait so long before action?

It appears from the record, and about this there is no dispute, that for a long time after Bell's patent issued, Gray conceded and acknowledged that Bell was the first original inventor. He also regarded the invention as a trivial and unimportant one, a scientific toy. As early as November 1, 1877, he had written his attorney, Baldwin :

"Bell's talking telegraph.—It only creates interest in scientific circles, and as a scientific toy ; it is beautiful, but we can already do more with a wire in a given time than by talking. so its commercial value will be limited."

This was after Gray had seen Bell's telephone at the Centennial in 1876, at Philadelphia, and had heard it talk. In letters to Mr. Bell and others, in lectures at Chicago and elsewhere, in 1876 and 1877, Gray publicly and privately conceded priority of the invention of the telephone by which articulate speech could be transmitted to Bell, and awarded him the honor of being the inventor. That he did these things is fully conceded by Gray.

Gray was a prolific inventor, and had prior to 1876 taken out a number of patents. These related to multiple and harmonic telegraphy, among other things. Some of these inventions subsequently became the foundation of his claim to have invented the telephone ; for instance, his patent No. 166,095. At an early date he had interested a Dr. Samuel S. White in his inventions. At the time Dr. White became interested Gray had never succeeded in transmitting speech, but, undoubtedly, was speculating upon the subject. Recognizing Bell as the inventor, Gray filed no application for a speaking telephone until October 29, 1877, although he says in a statement prepared and published in April, 1878 :

"As early as March, 1874, Dr. Samuel S. White, of Philadelphia, had purchased an interest in all my telephonic inventions which I had made or might thereafter make."

That this would include and was subsequently made to include Gray's caveat, cannot be doubted, as subsequent important transactions and Gray's evidence abundantly show.

Being thus jointly interested, Gray and White concluded to conduct their business under a corporate organization, and by

articles dated May 26, 1876, they organized "The Harmonic Telegraph Company," with a capital of five thousand shares one hundred dollars each; of which Gray had twenty-four hundred and seventy-five; White, twenty-four hundred and seventy-five; Andrews, about fifty, and some others a few shares.

Evidently this organization looked to the exploiting of Gray's patents, and did not contemplate the subjects of telephones so much as the introduction of telegraphic inventions; for at this date Gray regarded the telephone as a toy and Bell as the inventor.

There existed at this time the Gold and Stock Telegraph Company, which controlled the inventions of Edison, Dolbear and others. In the fall of 1877, Gray and White, representing the Harmonic Telegraph Company, opened up negotiations with the Gold and Stock Telegraph Company for the sale to them of all inventions Gray had made or might make thereafter, relating to speaking telephones. By this time it had been demonstrated that the telephone was not a toy; its commercial importance was beginning to be understood, and it was being introduced.

In this condition of things, being under the belief that Bell was the first inventor, having organized the Harmonic Telegraph Company, and negotiating for the sale of his telephonic inventions to the Gold and Stock and the American Speaking Telephone Company, about to be organized, Gray filed his applications Nos. 1, 2 and 3. October 29, 1877. He says in his affidavit of November 9, 1885:

"Being in this belief, I did not take steps to file my application upon my caveat promptly, but the matter rested without any application until November 1877. This long delay will be understood, in view of what I have already stated. Some time prior, however, to the filing of said application, it was suggested by the American Speaking Telephone Company, under the idea that it was the owner of said (my) caveat, *that some advantage or benefit might be derived from it.* [That is, Gray filing his applications.] I accordingly filed my applications. This was my act thus done, and done by my counsel at the request of said company."

He is mistaken about the suggestion coming from the American Speaking Telephone Company, for that was not organized at the date he filed his applications. It came either from his own company, the Harmonic, or else from the Gold and Stock or the Western Union. It was probably the latter companies, which had become owners of Edison's, Dolbear's and other inventions, and who knew that sooner or later a bitter controversy must arise between themselves and the Bell Telephone Company as to the validity of Bell's patents. It was probably these latter companies, which were then negotiating with Gray and White, as the owners of these inventions, who advised Gray to file his applications, expecting "that some advantage or benefit might be derived from it." These companies expected to become interested in Gray's inventions as the result of pending negotiations, and thus, having control of Gray's inventions, as well as Edison's, Dolbear's and others, they would be better equipped to enter the legal lists with the Bell Company. There is no other possible explanation of Gray's course in filing his three applications and making the oath to them, when he, as he now testifies, still believed that Bell was the first inventor. It was long after this that Gray changed his belief, though he has not seen proper to state the precise time when the change occurred. As will presently be seen, up to and long after the decision of the Examiner of Interferences, he conceded priority to Bell, except as to issue G.

The American Speaking Telephone Company was organized pursuant to an agreement of date November 17, 1877, between the Harmonic and the Gold and Stock Companies and the Western Union Telegraph Company. The Harmonic Company was to transfer to the former,—

"all existing and future patents and inventions owned and controlled by it or which may thereafter be owned and controlled by it, so far as the same *relate to speaking telephones*, more particularly the *patents and inventions, and right to future patents and inventions of Elisha Gray.*"

The Gold and Stock Company were in like manner to transfer to the American Speaking Telephone Company the patents and inventions, present and future, of Amos E. Dolbear.

These agreements were subsequently carried out. The American Speaking Telephone Company organized under articles dated December 1, 1877, and, the transfer made, Gray received large blocks of stock in the new company, was a director thereof, and also held important and responsible positions for the company. It is somewhat difficult to understand just what position Gray assumes with reference to these transactions. He now declares that for some years he *believed* that he had transferred his telephonic inventions, including those now in controversy, and virtually that all the parties with whom he dealt *believed* that they had acquired them. He does not assert that he did not *intend* to assign them and transfer them to the Harmonic Company, of which he was an officer and stockholder, or that they were not intended to pass to the American Speaking Telephone Company. But he appears to simply assert that the formal conveyances from himself to the former company were not in law sufficient, because the inventions were not specifically named or described or because the contract was of an executory character. Precisely what he relies on is not definitely known. But that he believed he had assigned and transferred them, and that he received large and valuable consideration for the supposed transfer is as clearly shown as that the parties receiving the transfers believed they were thereby acquiring the right and title and paying for them.

This is shown by Gray's own statements and testimony and by the subsequent litigation between Gray's supposed assignees and the Bell Company, both in the Patent Office and in the courts, in all of which Gray took part, both as party and as witness, *believing* that he had invested the American Speaking Telephone Company and the Western Union Telegraph Company with the title to his telephone inventions. What were these contests about? The telephone. To suppose that this contest, extending until recently decided in the United States Supreme Court, was one that did not include Gray's telephone, and that those great companies, as well as Gray, were resisting the Bell Company in any other belief than that they owned Gray's inventions, is incredible.

Thus organized and controlling the several inventions and patents of Gray, Edison and Dolbear, the American Speaking Telephone Company began to put out telephones in the winter of 1877-8, and before the close of 1879 had put more than twenty thousand into commercial use. This company paid the expense of preparing and presenting Gray's applications, the erection of necessary telephone lines, material, bells, batteries, etc.

Peter A. Dowd was an agent of the American Speaking Telephone Company, and was engaged in their telephone business. In September, 1878, the Bell Company at Boston sued him and the American Speaking Telephone Company and the Western Union Telegraph Company, as infringers of the Bell patents, and thus the expected contest was begun. The defence of the suit was assumed by the Western Union and associated companies. It was determined to set up Elisha Gray as a prior inventor of the speaking telephone and of various important features of telephones then in use. Gray prepared a printed statement of all he had done toward the invention.

It occupied nearly 100 pages. While it does not appear that he had changed his opinion as to the original inventorship, the importance of the pendency of his three applications in the Patent Office and of the interference between them and Bell's patents, which had been declared in the mean time, is apparent. The answer to the Bell Company suit justified under Gray. Every exertion appears to have been made to present Gray's inventions in the strongest light. Besides furnishing the statement alluded to, Gray went to New York and spent most of the winter and spring of 1878-9 in assisting in the preparation of the defence. He also gave his testimony, and in the present procedure it is not pretended that he can add anything or throw any new light upon the subject or history of his invention. He has disclosed everything and has no more to tell.

There were thus pending contemporaneously two contests or proceedings, the interferences in the Patent Office and the Dowd suit in the United States Circuit Court for the District of Massa-

chusetts. The taking of evidence progressed, but that in the Dowd case was completed first. It was practically closed on the 19th of September, 1879, including the complainants' evidence-in-chief, the defendants' evidence-in-chief and the complainants' evidence in rebuttal. No question is made but that up to this date the contest was most vigorously and bitterly conducted, the Bell Company claiming under the Bell patents and the Western Union having control of Edison's, Dolbear's and Gray's inventions, as was supposed and believed. Eminent counsel represented the respective parties, and the litigation became a matter of public notoriety and its determination one of public interest.

At this stage of the litigation, when the evidence had been concluded and counsel were in condition to take a definite survey of the facts, counsel, including Mr. Gifford, advised the Western Union and the associate companies that the Bell patents were valid and that the defence must fail. But valuable improvements had been made upon the speaking telephone which were deemed important to the commercial success of the original invention, and the Western Union and associate companies controlled these,—such as Edison's carbon telephone, the Page patent covering the induction coil, etc. With impending defeat before them, the Western Union Company proceeding upon the basis of these valuable improvements, opened negotiations with the Bell Company to compromise the litigation and unite all patents relating to the speaking telephone upon terms to be agreed upon. Such an agreement could not well have been proposed or made unless it had been believed that Gray was not the first inventor, and also that the Western Union had acquired his inventions, for his inventions had been those under which they had justified, and to settle that litigation, leaving his inventions out, would have been absurd.

This settlement was effected and a preliminary memorandum was executed on September 27, 1879. This preliminary agreement was a voluminous instrument settling and determining the rights of the various parties in and to these various inventions, and determining in what manner the telephone business should be conducted, etc. It is not necessary to set the agreement out with any great particularity. It appears that when this preliminary memorandum was made it contemplated that it should subsequently be reduced to a more complete and perfect form, which was afterward done, of date November 10, 1879. There is no claim that there is any essential difference between the memorandum and the subsequently executed formal instrument, except in Article 16, which provides:

"The existing suits and interferences shall be disposed of as counsel of the parties of the first and second parts may advise to recognize and protect the rights of the respective inventors to their several inventions, subject to the orders of the courts and the decisions of the Patent Office."

This paragraph in the memorandum read as follows:

"The suits and the interferences shall be disposed of as counsel for the respective parties may advise to carry out the purpose of this agreement, so long as it shall continue in force."

Article 17 provided that the contract should go into effect as of November 1, 1879, and remain in force for seventeen years thereafter. Pursuant to this contract a decree was entered in the Dowd case on the 4th of April, 1881, adjudging Bell's patent to be valid and perpetually enjoining the infringement of the same. This decree recites the fact that it is by consent of parties.

The evidence in the Dowd case was, by stipulation of all parties to the interference proceedings transferred and introduced in the interferences as evidence to be used and considered in those cases.

The effect of the contract of November 10, 1879, by which the Dowd suit was settled, was to invest the Bell Telephone Company with the ownership of all the telephone inventions, which at that time were supposed and believed to include Gray's inventions, and obligated it to pay to the Western Union Telegraph Company twenty *per centum* of all rentals or royalties received or rated as paid by licensees or lessees for speaking telephones, and also twenty *per centum* of the net profits of the manufacture of telephones made in the United States for export.

As further explaining Gray's course in failing to file his applications sooner than he did and also in making the subsequent concessions hereinbefore referred to in favor of Bell as the prior inventor, it is proper to call attention to some additional circumstances which appear in the history of the matter.

Bell's application was prepared and executed January 20, 1876. Gray's caveat was prepared and executed February 14, 1876, and both were filed in the Patent Office on the same day, viz, February 14, 1876. The Examiner at that time in charge of the division to which they were referred, following what appears to have been the practice theretofore, treated Gray's caveat as having been filed first, within the meaning of the statute, and issued notices to the parties, advising them of the fact of an apparent interference between the application and the caveat, and required Gray to proceed and file his application within the ninety days if he desired to avail himself of the caveat.

Bell's attorneys at once made an inquiry of the Office to know the precise date on which the caveat was filed. This was a matter which of course they were entitled to know, and finding that the date of filing the caveat was the same as that of Bell's application, they insisted that it was proper to determine which was in fact filed first, regardless of the date or day. This matter was then referred to the Commissioner, who instituted an investigation and ascertained to his satisfaction at that time that Bell's application was filed first, and as matter of law he held that the caveat was not filed within the time or before the application, within the meaning of the patent law, and directed that the notices which had been theretofore issued to the parties should be withdrawn, and that Bell's application should not be suspended to await action on Gray's part.

This investigation made by the Commissioner at that time appears to have been conducted as any other investigation would be in the Patent Office under similar circumstances—*ex-parte*. It was instigated, of course, by Bell's attorneys. Gray, however, had he manifested the same diligence, could have set on foot a similar investigation and been heard; indeed, the record discloses the fact that Gray's attorney, on March 3, 1876, advised his partner, S. S. White, of the situation, and added:

"We could still have an interference by Gray's coming down to-morrow and promptly filing an application for a patent. If you want this done, telegraph me in the morning on receipt of this and I will have the papers ready in time to stop the issue of Bell's patent; but my judgment is against it, as Gray made the invention, as I understand it, while here, after Bell's application was sworn to. He may, however, have invented the resistance part of the application at an earlier date, and Bell's claim is for the system of graduated interruptions by a varying resistance instead of the abrupt interruptions, as I have mentioned.
(Signed) WM. D. BALDWIN."

Neither Gray, nor his partner White, responded to the suggestion of this letter. No application was filed, and Bell's patent issued.

Quoting now from Gray's affidavit of November 16, 1885, this explanation of his inaction is given:

"At the Centennial Mr. Bell exhibited a telephone which transmitted articulate speech. I witnessed the exhibition. He did not use a liquid transmitter on this occasion, but used an instrument very nearly resembling the receiver of my invention. I communicated this fact to my counsel and requested his opinion as to how my case stood in view of said fact, *and he informed me that practically my claim was defeated*, that Bell's application was filed on the same day as my caveat, and that Bell having made an instrument that successfully transmitted articulate speech, he occupied a better position and would undoubtedly succeed.

"Upon this advice of my counsel and my friend I acted. I had the fullest confidence in him. I believed that he was not only faithful in all respects, but that he had the necessary learning, ability and experience to advise me rightly. In the latter it seems I was mistaken, but I did not for a long time find out the mistake, and did not know that the advice thus given was wrong and not in accordance with the law, as I am now advised.

"All my subsequent correspondence, admissions, statements and interviews must be construed with this in mind, and in view of the fact that I supposed I had parted with all my pecuniary interests in this and other inventions, and was therefore only interested as to my reputation as an inventor, and it seems my counsel, so called, had the same idea in view, as stated in his letters of October 24 and 29, 1881, as set forth in his last affidavit in which he wrote as follows:

"'I am devoting my argument more to a vindication of your position than to attacking your adversary, though I am stating some facts in regard to Bell and Edison very plainly.' In the letter of October 29, 1881, he says: 'Enclosed find an advanced copy of my argument in your behalf in the speaking telephone interference case. My object has been mainly to place you right before the public on the scientific side of the question. I hope I have succeeded, but I am not proud of the performance."

This state of mind on the part of Gray appears to have continued down to a point of time which was later than the decision of the Examiners-in-Chief in the interference proceedings.

Mr. Baldwin was Gray's attorney in preparing his caveat and his applications, and also in conducting the interference. Baldwin says that upon the settlement of the Dowd case, in November, 1879, it was understood and agreed that the questions of priority pending in the interferences involving a personal pride and feeling to the parties should be settled by adjudication in the Office.

"That particular plan was in accordance with a correspondence between Mr. Gray and myself. The plan set forth in that correspondence was faithfully followed by me throughout to the best of my ability. Moreover, Mr. Gray was kept advised from time to time of the plan on which the argument and appeal were made."

The record is very satisfactory that Mr. Baldwin kept his client, Mr. Gray, constantly advised of what was being done in the cases. The correspondence is produced and not controverted. The relations of the Bell Telephone Company to the applications of Gray, Dolbear and Edison, which were the result of that settlement, were thoroughly understood by Gray at the time. In a printed brief prepared by Gray's counsel in the interferences it was stated that articulate speech had not been transmitted by either of the inventors or others prior to the Bell patent; that Bell's first reduction to practice was after his patent issued, and by means of a liquid transmitter. It was also stated in the brief:

"When, however, in the course of subsequent litigation, the fact was developed that as between Gray and Bell, the latter really was the first to conceive the invention of transmitting articulate speech and to reduce the invention to practice, Gray voluntarily came forward, like the straightforward, fair-minded man that he is, and conceded that fact to his rival. We shall therefore retire from the contest over the issues in cases A and B, so far as relates to the question of electrical transmission of articulate speech. The ground was so thoroughly cultivated then (in the Dowd case), that it was not seen where it could be improved by harrowing it again, and the entire record was accordingly stipulated into this case (the interference), that we might have the benefit of the numerous and valuable facts developed. The fifth claim of this patent has since been interpreted and sustained by the courts as broadly as Bell himself could desire in the recent case of American Bell Telephone Company *v.* Spencer, 20 O. G., 229."

It also appears that copies of this brief were furnished Gray by his counsel, Baldwin, of which he acknowledged the receipt in a note dated New York, November 14, 1881, as follows:

"*Dear Baldwin,*—I received the patents and also the copy of your brief The letter was a very able document, and you did yourself 'proud.' I would like a few copies for distribution."

In response to this fifty copies were sent to Gray, and it does not appear that he ever expresssed any disapproval of its contents. After the decision by the Examiner of Interferences Mr. Baldwin advised him in a note, "My opinion is to appeal on the receiver cases and let the rest go." This course was either approved or acquiesced in by Gray, and the appeal was subsequently taken as explained from the decision so far as it is related to the receiver, issue G, with the results heretofore set forth, so that it must be recognized as one of the established facts in the present matter that Gray's recognition of Bell as the first original inventor, as explained above, was made deliberately and publicly.

In order more fully to understand the question of collusion, as urged in these proceedings, it is necessary to state, in this connection, that prior to November 2, 1880, negotiations had been entered into between the American Bell Telephone Company and McDonough, with reference to the purchase by the company of McDonough's inventions in telephony, and on the second day of November, 1880, a written contract was executed between those parties of which the following is a copy:

"This agreement, made the second day of November, A. D., 1880, by and between James W. McDonough, of the first part, and the American Bell Telephone Company, a corporation, of the second part, witnesseth:

"In consideration of *five thousand dollars*, paid by said corporation to said McDonough, the receipt of which is hereby acknowledged, it is agreed as follows:

"If said McDonough on his inventions shall obtain a *valid* patent, covering broadly the art of transmitting articulate speech by electricity, he shall assign the same to said corporation, and said corporation shall thereupon pay him the sum of *two hundred thousand dollars* therefor. If said McDonough, on his own inventions, obtains a *valid* patent, covering broadly variable-resistance contact transmitters for electric speaking telephones, he shall assign the same to said corporation and said corporation shall thereupon pay him the sum of *fifty thousand dollars*.

"If said McDonough on his invention shall obtain a patent covering broadly magnetic receivers for electric speaking telephones, he shall assign the same to said corporation and said corporation shall thereupon pay him the sum of *fifty thousand dollars*.

"It is understood that Mr. McDonough is not to take out foreign patents in such a way as to shorten the life of the United States patents, which, if granted, will be subject to this agreement.

"Signed and sealed at Boston on the first day above written.

"*This agreement is not to be taken as any manner of admission by either party, as to the validity or invalidity of claims made by the respective parties*

("Signed) THE AMERICAN BELL TELEPNONE COMPANY.
By W. H. FORBES, *President*.

"In presence of C. EMERSON as to W. H. F.
(Signed) JAMES W. McDONOUGH. [Seal]

"Received $5,000, as within, November 2, 1880.
(Signed) JAMES W. McDONOUGH."

Attention is called to the closing paragraph, which clearly indicates that neither party contemplated assisting the other in procuring their respective patents, but that each party evidently undertook to look after his own interests in the prosecution of his claims.

With this statement of the facts relating to Gray's case I now proceed to consider the merits of his petition. In advance it must be understood that the case is before me upon a petition for rehearing, in which I am asked to set aside all of the orders heretofore made and to reinstate the cases for reconsideration upon new and additional evidence and upon the merits broadly. The decision which is sought thus to be set aside was rendered by Mr. Commissioner Butterworth in March, 1885. The subject was allowed to pass over the entire administration of Mr. Commissioner Montgomery for presentation or consideration other than to file the petition with an indication that it should not be acted upon until further motion should be made, and it now comes before me, the second successor of the officer who decided the case.

Rule 144 of the Office, which has been in force during all this period, provides as follows:

"Cases which have been deliberately decided by one commissioner will not be reconsidered by his successor except in accordance with the principles which govern the granting of new trials."

An attempt is made in argument to show that this case was not deliberately decided by Commissioner Butterworth, for the reason that in his decision he made use of the following expression:

"If on examination of the evidence and consideration of the arguments I had become convinced that the findings and decisions of the Examiners-in-Chief were erroneous, or if a serious doubt in that behalf had been raised in my mind, I would have felt constrained to leave the case undecided, to be reheard by my successor. Had I reached a different conclusion it would have been desirable that the reasons for overruling the decision of the board should be stated at length"

I am not able to see the force of the argument that this expression indicates that Mr. Butterworth's decision was not one deliberately made. On the contrary, if any inference can be drawn from it, it is that the case was elaborately considered and deliberately determined, and that he had no doubt about the result which should be reached, and accordingly announced his decision. The record shows that the case was argued at length and was given great consideration, and it is this, which in my judgment, determines whether a case has been deliberately decided or not. It follows, therefore, that the case is not before me upon its merits, and I am not in a situation to be called upon to grant a rehearing upon a mere preponderance of evidence, as if the case were before me originally, where the preponderance of evidence would prevail; but I am to bear in mind that this controversy has extended through a period of years in the Office, that it has passed through all of the tribunals, and with a single exception, viz., as to issue G, the decisions have all been uniformly in the same direction, and a case must now be presented which justifies the exercise of a judicial discretion before a rehearing can be granted, and this must be done by evidence either of error an in the conclusions of fact or in the application of the law of a very clear and satisfactory character.

At every stage of the contest in this Office, one of the serious and important questions has been the effect and legal construction to be given to the Bell patent of March 7, 1876. The Examiner of

Interferences felt concluded by the construction which had been put upon that instrument by the commissioner and the courts, evidently referring to the Spencer case. The same is true of the Examiners-in-Chief, who cite the Spencer case and the Dolbear case. Before me it has been urged with great force of argument that those cases were not authoritative: that Bell's patent was not a patent for a telephone, but for a multiple telegraph, and that Bell in fact had never invented the telephone. But I am relieved of any further consideration of these questions by the recent decision of the Supreme Court in the Telephone cases, 126 U. S., where that tribunal has finally and definitely settled such questions.

That court says:

"In the present case the claim is not for the use of a current of electricity in its natural state as it comes from the battery, but for putting a continuous current in a closed circuit into a certain specified condition, suited to the transmission of vocal and other sounds, and using it in that condition for that purpose. So far as at present known, without this peculiar change in its condition it will not serve as a medium for the transmission of speech, but with the change it will. . . . We see nothing in Morse's case to defeat Bell's claim; on the contrary, it is in all respects sustained by that authority. It may be that electricity cannot be used at all for the transmission of speech, except in the way Bell has discovered, and that therefore, practically, his patent gives him its exclusive use for that purpose; but that does not make his claim one for the use of electricity, distinct from the particular process with which it is connected in his patent. It will, if true, show more clearly the great importance of his discovery, but it will not invalidate his patent. But it is insisted that the claim cannot be sustained, because when the patent was issued, Bell had not in fact completed his discovery. While it is conceded that he was acting on the right principle and had adopted the true theory, it is claimed that the discovery lacked that practical development which was necessary to make it patentable. In the language of counsel, 'there was still work to be done and work calling for the exercise of the utmost ingenuity, and calling for the very highest degree of practical invention.'

"It is quite true that when Bell applied for his patent he had never actually transmitted telegraphically spoken words so that they could be distinctly heard and understood at the receiving end of his line; but in his specification he did describe accurately and with admirable clearness his process; that is to say, the exact electrical condition that must be created to accomplish his purpose, and he also described, with sufficient precision to enable one of ordinary skill in such matters to make it, a form of apparatus, which, if used in the way pointed out, would produce the required effect, receive the words and carry them to and deliver them at the appointed place. The particular instrument which he had, and which he used in his experiments did not, under the circumstances in which it was tried, reproduce the words spoken so that they could be clearly understood; but the proof is abundant and of the most convincing character, that other instruments, carefully constructed and made exactly in accordance with the specification, without any additions whatever, have operated and will operate successfully. A good mechanic with proper skill in matters of the kind can take the patent and by following the specification strictly can without more construct an apparatus which, when used in the way pointed out, will do all that it is claimed the method and process will do. . . .

"The law does not require that a discoverer or inventor in order to get a patent for a process must have succeeded in bringing his art to the highest degree of perfection. It is enough if he describes his method with sufficient clearness and precision to enable those skilled in the matter to understand what the process is, and if he points out some practicable way of putting it into operation. This Bell did. He described clearly and distinctly his process of transmitting speech telegraphically by creating changes in the intensity of a continuous current or flow of electricity in a closed circuit, exactly analogous to the changes of density in air occasioned by the undulatory motion given to it by the human voice in speaking. . . .

"The apparatus as 'herein-described,' which is included in the claim, is undoubtedly one in which an electro-magnet is employed and constructed 'substantially as set forth' in the specification. One acting on the variable resistance mode is not described further than to say that the vibration of the conducting wire in mercury or other liquid included in the circuit occasions undulations in the current; and no other special directions are given as to the manner in which it must be constructed. The patent is both for the magneto and variable-resistance *methods*, and for the particular magneto *apparatus* which is described, or is equivalent. There is no patent for any variable resistance apparatus. It is undoubtedly true that when Bell got his patent he thought the magneto method was the best. Indeed, he said in express terms he preferred it, but that does not exclude the use of the other if it turns out to be the most desirable way of using the process under any circumstances. Both forms of apparatus operate on a closed circuit by gradual changes of intensity and not by alternately making and breaking the circuit or by sudden and instantaneous changes, and they each require to be so adjusted as to prevent interruptions. If they break it is a fault, and the process stops until the connection is restored."

It is to be observed that in so far as the Supreme Court gave a construction to the Bell patent and held that it disclosed the invention, they were united and there was no dissenting opinion.

It has thus been established in my judgment definitely and finally that Bell's patent discloses the invention of the telephone, covering both the method and the apparatus,—one composed of a transmitter, a closed circuit and a receiver; that this patent relates back to the date of the application, and also to the date of its execution, viz., January 20, 1876, as the first original date of conception. It does not follow, of course, unless established by other evidence, that Bell was the first inventor, or that he was an original inventor. But whoever attempts, either in these interference proceedings or in an infringement suit or suits, such as those decided in the Supreme Court of the United States, to antedate Bell's invention and establish an earlier invention, must prove by clear and satisfactory evidence a prior conception and prior reduction to practice to the date of Bell's application, or that having made an earlier conception than he did, such inventor diligently prosecuted it to a reduction to practice. These propositions may be supported by innumerable decisions of the Commissioner and of the courts, but I see no occasion to cite them.

INTERFERENCES A, B, C, E, F.

First comes the inquiry whether there is anything submitted to me in the record which justifies me in reaching a conclusion that there was any error in the action of the Examiners-in-Chief with reference to the date of Gray's invention, or whether in fact he ever did invent the telephone. In this consideration I exclude for the present issue G, which relates to the receiver.

A most careful and laborious examination of the evidence and arguments submitted failed to impress me with any want of satisfaction in the facts as found by the Examiner of Interferences. It is conceded by all parties that Gray's caveat, prepared and filed February 14, 1876, was the first description he ever made of the invention covered by the issues under consideration. Prior to that date the subject was evidently one of speculation and experiment. As is said by the Examiner of Interferences:

"His energies were directed exclusively to the transmission of musical tones and their utilization for telegraphic and other purposes, no attention being given to instruments for the *reception*, transmission and *reproduction* of articulate speech until along in February, 1876, and although he claims to have had some conception of the *possibilities* late in the fall of 1875 he neither disclosed them to others nor clothed them in any fixed and positive form until he made the sketch for his caveat, February 11, 1876."

Gray says:

"I was *convinced* that the receiver would produce articulate words, inasmuch as it *seemed* to be capable of reproducing any form of vibration that I was *able* to transmit. I remember speaking of this to different ones about this time; I may have mentioned this before the 1st of April, 1874, or it may have been a little while after. My impression is that I first mentioned it before. My conception then of an instrument for transmitting articulate speech was one of a complicated character, having a series of transmitting points adapted to respond to all the tones of the human voice, somewhat similar to the apparatus referred to in my caveat of February 14, 1876."

The description contained in the caveat is as follows:

"I contemplate, however, the use of a series of diaphragms in a common vocalizing chamber, each diaphragm carrying an independent rod and corresponding to a vibration of different rapidity and intensity, in which case contact points mounted on other diaphragms may be employed."

When called upon to explain the construction of the apparatus thus ambigously outlined in his caveat, Gray confesses that it was a general idea, not clearly defined in all its details, and based upon a theory which has since proved to be false. The instrument was never constructed by him.

It is evident that while Gray's caveat may be accepted as a conception of the invention of the telephone, a method and also an apparatus, Gray himself did not fully understand it, and, as stated, was unable to explain the mode of its operation. In other words, even after filing the caveat and before the true secret of the telephone had been made known by the publication of Bell's patent and his lectures and experiments at the Centennial, Gray still adhered to the old idea that articulate speech must be transmitted upon the multiple-telegraph principle, by the use of a series of diaphragms in a common vocalizing chamber, each diaphragm carrying an independent rod and responding to a vibration of different rapidity and intensity; so that the earliest possible date of conception which can be given to Gray is February 11, 1876. But of course this cannot affect Bell's patent, for the reason that the evidence is satisfactory and it is absolutely conceded by Gray that he did not reduce his invention to practice for a long time after the issuance of Bell's patent; that in the mean time, regarding the invention as of trivial importance, he neglected it altogether and turned his attention to other inventions to the exclusion of

this, so that the Examiners-in-Chief were justified in finding that Gray was neither diligent in filing an application in the Office nor was he diligent in reducing to practice, and consequently, under well-settled principles of law, cannot be given the benefit of his date of conception as against another independent inventor.

But Bell is shown to have conceived the invention on the 20th of January, 1876, when he prepared his specification and showed it to others and subsequently filed it in the Office, on the 14th of February, as heretofore stated. There is no doubt that Bell prosecuted his discovery with great diligence, at once filing his application and obtaining the patent at the earliest moment possible.

These facts are not only conclusive and convincing, but the conduct of Gray afterward is equally satisfactory as to the same. His concessions were made at a time when he was vastly interested in making the most thorough examination of the facts before he should concede anything. His omission to file his applications until nearly two years after the date of his caveat, his concessions made in the Patent Office as matter of record in a controversy, and the further fact that when he filed his applications it does not appear that he had changed his belief as to who was the first inventor, but was acting in the interest and under the direction of the parties who had in view a litigation with Bell as to the validity of his patent, all serve to confirm the correctness of the decisions of the Office giving priority to Bell.

So far, therefore, as the present petition of Gray may be said to be a motion for a rehearing of these issues upon the alleged ground of error in law or in fact, or both, in the decisions to be reviewed, it might well be regarded as disposed of here; for Gray proposes no new or additional evidence as to the dates, nature or character of his own invention. What he did as an inventor, the experiments he made, the date of conception, his caveat, applications, etc., remain fully stated, described and disclosed in the evidence already submitted by him. He does not propose to add anything to the evidence upon which the several decisions before the Office have heretofore proceeded; nor does he pretend that the collusion and misapprehension on his part or the supposed misadvice of his counsel, or other matters to be hereinafter considered, prevented him in any manner from giving his testimony, from giving all the facts—the whole truth—with reference to the history of his own efforts and transactions as an inventor. Upon the evidence introduced and considered the decisions were correctly made and the award or priority of invention was justly given to Bell. With his patent construed and sustained as it has been in the courts Bell must upon the record before the Office be held to have been the first to conceive, the first to disclose and by his patent give the invention to the world; the first to reduce the invention to practice, first, constructively by his patent, and actually, later, by the transmission of speech in the early part of 1876, as explained.

But in his petition to reopen the interferences Gray seeks to go farther and affect these decisions in the Office upon the evidence adduced by a direct attack upon the procedure in the Office, and by the introduction of new and additional evidence to establish the alleged fact that Bell was not an independent inventor, but pirated the invenion from him, Gray.

Without presenting all the points *seriatim* or following the petition and argument in their exact order, the several propositions may be stated as follows:

First. As to these issues before any substantial progress had been made in taking the proof in these interferences. The Bell Telephone Company, owning Bell's two patents, had acquired or supposed they had acquired, by assignment all the other patents and inventions supposed to possess any value involved in the interferences, including Gray's; that from thence on the proceedings in the interferences were mainly under the management and control of said company and its associates with the view of reaching such result as they desired, viz., priority to Bell, said company paying counsel on both sides and all other necessary expenses, and the proceedings were therefore collusive and should be disregarded and set aside.

Second. That the concessions of priority made by Gray in favor of Bell were made under incorrect and improper advice of his (Gray's) counsel, who later on in the interference was paid for his services by the Bell Telephone Company combination, acting under the Dowd settlement of November 10, 1879, and was under their influence; and that it was in consequence of this improper advice under these conditions that he declined to appeal from the decision of the Examiner of Interferences as to these issues. Also that these concessions were made and his subsequent course governed by the belief that Bell was in fact an original inventor, had actually filed his application in point of time earlier than Gray's caveat had been filed; whereas he now believes that neither of said conditions existed, but on the contrary Bell had fraudulently secured access to his caveat, purloined his invention, and carried the description therefrom into his application.

Third. Upon the ground of newly-discovered evidence, important and material, which petitioner did not know to have existed in time to produce it before the Office, which new evidence will show that those portions of the Bell specification containing the description of the variable-resistance appliances were not contained in it when originally filed and were not in any of Bell's previous specifications or writings; that he obtained the knowledge and description of them from his fraudulent inspection of Gray's caveat and then fraudulently caused them to be written into his application after it had been filed, and so he, Bell, was not, in respect to them, an original inventor.

Fourth. That the decisions of the Office were erroneous in law and in fact, because, as a matter of fact, Gray's caveat was filed before and not after the filing of Bell's application, and consequently it was error to give Bell the status of a patentee, the rule being in such cases that Bell was to have been regarded as a mere applicant for a patent on an equal footing with Gray.

1.—THE ALLEGED COLLUSION.

Gray alleges that the proceedings in these interferences in the Patent Office were collusive because the Bell Telephone Company, as was supposed, had acquired all the interests involved and was, therefore, able to mould and control the decisions in such form as it saw proper. This proposition, of course, depends upon whether this company had then acquired Gray's inventions. He now claims that it had not, that the inventions then belonged and still belong to him, and that it was merely a matter of supposition at the time that it had acquired his inventions. He does not pretend that in consequence of that belief he was in any manner deterred from presenting all his evidence and receiving all the consideration to which he was entitled, or that he can now add anything to the evidence or present any new consideration as to the origin or date of his invention.

It is rather a peculiar situation in which he finds himself. He is forced to assert that the company had acquired his inventions in order to establish the collusion, and is required then to deny that it had so acquired them in order to find a standing for his petition to vacate the decisions upon the ground of collusion. His counsel cite in support of the proposition the following authorities: Cox *v.* Hardwick. Cases Temp. Hardwick; 237; Earl of Bandon *v.* Betcher, 3 Clark & Finnelly's Reports; Lord *v.* Veazie, 8 How., 251; Cleveland *v.* Chamberlain, 1 Black, 419; Wood Paper Company *v.* Heft, 8 Wall. 333; Gardner *v.* Goodyear Dental Vulcanite Company, 6 Fish. 329; Fletcher *v.* Peck, 6 Cranch, 147.

These decisions settle the proposition as stated by the counsel that courts will not try and adjudge cases in which there is no controversy or where the controversy has been settled by the parties themselves; nor will they try moot questions for the purpose of obtaining decisions affecting injuriously the rights of third parties; but none of them establishes that the courts will vacate or set aside their action where in the proceeding before the court, the court has been fully advised of the situation and relation of the parties and with full knowledge has proceeded and rendered judgment. Nor will the court vacate or set aside such judgment where the interests of third parties are not affected at the instance of the parties to the controversy, unless they have acted promptly and called the attention of the court to the settlement or the fact that there is no controversy as soon as that condition arises.

When these interferences were declared, and up to November 10, 1879, there could have been no collusion, for the reason that during this period the Bell Telephone Company had not acquired Gray's interest, and the contest between that company and the American Speaking Telephone Company and others was being hotly conducted. It is clearly established that the Patent Office was well advised, and all parties understood that the Bell Telephone Company had come to be the owner of most of the inventions involved, and had acquired an interest in that of McDonough (involved in issue G), and that the proceeding before the Office, after the settlement of November 10, 1879, was conducted in accordance with the practice which has existed from time immemorial. It is a matter of common occurrence, that interference proceedings are conducted after the inventions involved have been assigned to the same person or corporation. Counsel are employed to represent the respective inventors, take evidence and conduct the proceedings, and the decision of the Office is given for the purpose of ascertaining which of the inventors was the original and true inventor, within the meaning of the statute, in order that the assignee may obtain a valid patent. This practice has been assailed in argument as being irregular and improper and coming within the condemnation of the courts, as found in the decision just cited, but I do not think the decisions are applicable. In these interference proceedings, the public is interested in seeing that a valid patent issues, and the rules of practice are such as to require the procedure to be conducted to a conclusion. The Office is not always willing to award priority upon a stipulation between the parties, but requires that the award of priority shall be determined either by the record date of the parties, or by a satisfactory showing.

Under the English system a patent may be issued to the assignee of a number of applicants for the same invention, and his patent will be valid, provided either of the assignors was the real inventor. In such a case it cannot be presumed that the public will be injured by a patent issued to the assignee under such circumstances, for the reason that he represents the true inventor, although it may not be know at the time which of the several applicants was the true inventor. But under our system a judicial investigation is required by the statute to enable the Office to ascertain who was the true inventor. This requirement is on behalf of the public, or the third party, as it is sometimes called, for in an interference between a patentee and a later applicant, the public is distinctly interested in not having the monopoly prolonged by the issuance of a second and later patent, unless it be made to appear clearly that the applicant was in fact the original inventor justly entitled to a patent which he could obtain in no other way than by an award of priority. For this reason, as just suggested, the Office will not always receive the concessions of the parties themselves as to priority, but insists upon the evidence being produced; and this is just as essential in cases where both inventions belong to the same assignee as in other cases, for otherwise it would be placed in the power of the assignee to obtain a second patent and thus prolong his monopoly. Besides, the patent if issued for the invention of the wrong assignor would be void, if the fact should be developed.

It is urged by Gray's counsel that instead of having what he terms an apparent contest after the Bell Telephone Company had become practically the owner of the invention, it could have been settled upon the record, and Bell's application having antedated all others he would have received an award of priority, and that the course pursued in this case was due to a purpose on the part of what is called the combination of the Bell Company and its associates to secure a decision of the Office which could be used in courts and elsewhere, and was so used in several suits to support the *primas facies* of the patent and to obtain preliminary injunctions *pendente lite.*

It must be apparent that if the course suggested here had been pursued and an award of priority entered upon the record without the production of evidence, most of which, as already explained, was taken in a hotly-contested controversy, a still stronger objection could have been urged to the award of priority than is now brought against the course which was pursued. The question would have been asked then, why did they take an award upon the record and not pursue the ordinary course of taking testimony and establishing the fact upon an investigation? I can see no force in this objection. It may be true that the parties to these interferences at that time desired to secure a proper decision of the Office in order that they might derive such benefit from it as the law and the practice in the courts entitle them to; but it must be understood that at that time Gray was interested in the combination and was not only assenting to this course, but was promoting it, and it is difficult to see how he now can challenge the course of procedure in the Office upon these grounds, when his relation to it was such as stated. Even it were true that it is bad practice to award priority as was done in this case, after several interests have become vested in a single assignee, and that the practice should be abolished, it should be for future cases and not for the purpose of vacating and setting aside a case already disposed of, and especially not for the purpose of reinstating it for a re-trial.

It is evident that in the present petition Gray does not ask to have the decisions of this Office set aside so as simply to avoid them and leave the matter standing on Bell's patent alone, but for the secondary and more important purpose of having the contest reinstated and a re-trial and re-adjudication. In other words, he asserts that at the time the interferences were heard before the Office his mental condition was such that he believed the Bell Telephone Company with its associates to be the owner of his inventions; that his mental condition in this particular has since changed, and he desires the rehearing in order that it may be retried under the new mental condition. He may still, however, be in error as to the ownership, for the record presents strong evidence that his first belief or opinion was correct, and that the Bell Company is in fact the true and equitable owner of the inventions; and if this be true the supposed "collusion" would exist in the new trial as much as in the original.

As already stated, Gray promoted this interference procedure with full knowledge on his part of the settlement and of the facts which he now asserts constitutes collusion. He was also aware that it was conducted before the Office with full knowledge and consent on its part, and in accordance with its recognized practice with reference to such interferences. If this collusion exists, it existed then, and then was the time for Gray to have prompty moved, after November 10, 1879, to arrest proceedings in the Office, on the ground that to proceed further would be in violation of public policy and contrary to the rules recognized by the courts; but having failed to do this and not only allowed without objection, but promoted the controversy to a final decision, in order that he might succeed if he could and obtain an award of priority on behalf of his assignee, he has seen proper to wait until defeated before raising this question of collusion.

To permit this to be done would enable a party to trifle and experiment with the Office, accept its results if favorable and repudiate them if unfavorable.

But there is no judgment in these interferences which the rule of the courts in cases cited would require to be set aside. Priority was awarded to Bell and patents denied to the other interfering parties, much as a bill is dismissed for want of equity. No execution can issue nor other order be made affecting the rights of third parties injuriously or otherwise. The condition of parties remains precisely as it was before the interferences were declared, and as if nothing whatever had been done. In my judgment no court would interfere with an award of this character, and certainly not for the mere purpose of reinstating the contest.

It must follow that if the rehearing is to be granted at all it must be upon other grounds than the collusion referred to.

(2.) GRAY'S CONCESSIONS.

In his present petition Gray seeks to avoid the effect of his admissions and concessions in favor of Bell's priority, upon the ground that they were the result of misapprehension, improper advice of his counsel, and of fraud practiced by Bell in pirating his invention and deceiving him about the facts. He insists that his admissions have been introduced as part of the evidence sub-

mitted, and have had more or less influence in affecting the judgment of the Examiner of Interferences; that his concession of priority and withdrawal from the contest before the Examiners-in-Chief and his failure to appeal from their decision to the Commissioner were the results of the same continuing influences operating upon his mind and misleading him; that in consequence the decision should be set aside, he should be restored to his original status as a suitor, and should be allowed to retry the issues upon the original evidence and such new evidence as he can produce.

It is undoubtedly true that Gray's admissions were introduced in the evidence submitted, and that they were adverted to by the Examiner of Interferences in his decision. The examiner of interference says:

"In addition to the testimony we have the direct admission of Gray, in lectures, publications and letters to Bell, acknowledging that the latter was the first inventor of the apparatus for transmitting vocal sounds. In a letter to Bell, dated March 5, 1877, Gray says, referring to the matter of transmitting vocal sounds: 'I do not, however, claim even the credit of inventing it, as I do not believe a mere description of an idea that has never been *reduced to practice* in the *strict sense* of that phrase should be dignified with the name of invention.' It is clear, therefore, that Gray cannot be regarded as the inventor of the articulating telephone *per se*, and, recognizing that fact, he seeks to maintain such of his claims as are involved in these interferences upon other experiments and inventions made by him with respect to the transmission of sounds generally; and these will next be considered."

It is also true that the Examiners-in-Chiefrecognized G ray as having withdrawn from the contest as to all of the issues except issue G. They say:

"Gray, as before stated, has withdrawn from the contest as to all but this issue. His case does not rest upon the fact that he is the inventor of the art or even of an articulate transmitter, but upon the proposition, as stated by his counsel, that 'having invented, discovered and reduced to practice prior to the other contestants in this case, an apparatus involving the combination' of the issue, he 'is entitled to a patent for that apparatus with all its functions, incidents and capabilities, whether known at the time or not.'"

Even if the law will permit Gray in consequence of the alleged misapprehension, the improper advice of his counsel, and the alleged fraud of Bell, to be restored to his original status and to have a re-trial, it will do so only when we shall have clearly established these allegations as to the mistake, advice and fraud.

An examination of the decision of the Examiner of Interferences shows clearly that while he adverted to Gray's admissions he was by no means controlled by them. His decision proceeds upon the evidence of Gray and the other parties to the interference as to their several acts and proceedings in inventing, and upon this evidence he finds that Bell was the first inventor. As stated, he gives Gray as the date of his conception, February 11, 1876, the date of the sketch on which his caveat was based, and in my opinion no re-trial of the case will ever change that conclusion. His decision also shows that Bell's application, prepared January 20 and filed February 14, 1876, was regarded as his (Bell's) first conception, antedating Gray, and that Bell diligently prosecuted his application and secured his patent. This settled and still must settle beyond serious question Bell's priority, provided Bell's application and patent disclose the invention. Throughout the entire history of these interferences this has been one of the important questions contested. It was determined by the Examiner of Interferences, not upon any concession by Gray, but upon the decisions of the commissioner and the courts who had placed a construction upon the patent, holding that it did disclose the invention. The same decision in this particular was made by the Examiners-in-Chief. These tribunals did not cite the decisions of the courts for the purpose of ascertaining any date or priority as to Bell's patent, because whatever it disclosed it was certainly prepared on January 20, and filed on February 14, 1876, and was proof of a conception of whatever invention was disclosed by it. The courts held, and all the tribunals of the Patent Office have held, that it disclosed the inventions involved, and consequently priority of invention was awarded to Bell upon these facts. As heretofore stated, this question has since been finally settled by the Supreme Court of the United States in the telephone cases; so that it is palpable and clear that if Gray's admissions, which are found in the evidence, and his concessions, which were made as a matter of record in the interferences, be wholly withdrawn from the case, the conclusion as to the priority remains unaffected thereby.

As to the allegation that his counsel, Mr. Baldwin, gave Gray improper advice or was actuated by any improper influences, it is necessary to notice what the advice was and the circumstances under which Mr. Baldwin was placed with reference to his client. It is to be remembered that the advice to which Gray refers was given long before the interferences were declared and before the relations came into existence which grew up between the Bell Company and Gray and others, arising from the contract of November 10, 1879. It was at a time when no influence is claimed to have been operating upon Mr. Baldwin as an attorney except a proper regard for the interest of his client. Gray says:

"At the Centennial, Mr. Bell exhibited a telephone which transmitted articulate speech. I witnessed the exhibition. He did not use a liquid transmitter on this occasion, but used an instrument very nearly resembling the receiver of my invention. I communicated this fact to my counsel and requested his opinion as to how my case stood in view of said fact, and he informed me that practically my claim was defeated; that Bell's application was filed on the same day as my caveat, and that Bell having made an instrument that successfully transmitted articulate speech, he occupied a better position and would undoubtedly succeed."

Now, as to this advice, which is made the foundation of the charge of Gray, it is proper to say that the position assumed by Mr. Baldwin has been shown to have been correct by every decision in relation to the subject since it was given in the Patent Office and in the courts. As to Mr. Baldwin's subsequent course in the conduct of the case, it appears clearly that he acted diligently; that he kept his client, Gray, constantly advised of everything which was done, and in his subsequent relations with other parties and with the Bell Telephone Company, Gray was fully advised and made no objection whatever to them. Under such circumstances a court would hesitate long before granting a relief upon the allegations now presented by Gray or condoning either the advice or the conduct of his attorneys.

The allegation that Bell had fraudulently obtained access to Gray's caveat and had pirated the invention and was not himself the original inventor is a material one and will be considered further on in connection with the subject of the newly-discovered evidence presented by Gray.

But even conceding that Gray could establish these several allegations, there is a grave question whether he could be restored to his original position and be allowed to re-try and re-controvert these issues. If the matter involved were of such a character as to be purely personal between Bell and Gray and the controversy related to private matters alone, there is no doubt that a rehearing might be granted, but in this case there are, in fact, three parties; the public is a party interested and whose rights are to be protected as well as those of Bell and Gray.

Bell's patent has now been running since March 7, 1876. Gray has seen proper, as already explained, to concede priority to him; has come into the tribunal where the question of priority was being determined judicially, and has entered a plea awarding priority to Bell and withdrawing from the controversy. For a valuable consideration he has allowed other parties, supposing themselves to have become the owners of whatever inventions he had made, to invest largely in the property. He became himself personally interested as a stockholder, an officer, and in other particulars, in a corporation or a combination of corporations dealing with both the Bell property and his own, and inducing the public to become interested in them upon the strength of the decisions in this case and his recognition of Bell's priority. As he himself says, in one of his affidavits, as to these issues, he has acted and conducted himself upon the belief that Bell was the first inventor, and that the Bell Telephone Company was the owner of his (Gray's) inventions which they were regarding and inducing the public to regard as invalid and subservient to the Bell inventions. While receiving consideration for his supposed transfer of his inventions he has for several years regarded the matter as settled and disposed of, and until the filing of his present petition, which proceeds upon the assertion that he has obtained new and additional information, he has acted like one who has completely abandoned the invention. It is not necessary to a dispo-

sition of this petition to hold that Gray has actually abandoned these inventions to the public, if they do not belong to Bell, but I have little doubt that his conduct establishes such an abandonment.

The course pursued by Gray in disclaiming the invention, asserting and publicly indorsing Bell as the inventor, and for these reasons entering, before the Examiner of Interferences in October, 1881, his formal withdrawal from the contest, was with full knowledge that the invention then had been in public use for over three years, and that private enterprise throughout the country was investing vast sums of money in the promotion and introduction of the invention. While it is true he still asserted, both in the Patent Office and in the courts, his claim for invention of the receiver (issue G), yet as to the art or method and the transmitter as involved in these issues he made no move to avoid his disclaimer or reassert his inchoate right as inventor until he filed this petition, December 30, 1886, more than five years after his disclaimer, during all which period the public use contained and increased. Now, whether the invention belongs to the Bell Company as assignee of Bell or of Gray, regardless as to which of the two was the real inventor, the invention had gone into public use and innumerable persons had invested in it. Gray was a party to and had encouraged its public use with a disclaimer on his part. It is difficult to conceive much stronger evidence of abandonment on his part. (Pennock *v.* Dialogue, 4 Wash. 538; Kendall *v.* Windsor, 2 How. 322; Am. H. & L. S. Co., *v.* Tool Co., 1 Holmes, 503.) It is settled that abandonment may be after application is filed or patent issued (Bell *v.* Daniels, 1 Bond, 212); and after abandonment the inventor's right is as much beyond recall as when two years' public use intervene before application is filed. He cannot regain his inchoate rights or be restored thereto upon the ground that he was misled or deceived by fraud, etc. (Mellius *v.* Silsbee, 4 Mason, 108; Bowles *v.* Mason, 2 Am. L. T. R. (U. S.) 106; Jones *v.* Sewell, 3 Cliff. 563; Bell *v.* Daniels, 1 Bond. 212.)

Without absolutely holding that Gray has abandoned the invention there are considerations which are quite as fatal to his petition. It is evident that the public has a direct and immediate interest in the further prosecution of Gray's application for a patent. If the award of priority heretofore given to Bell can be vacated and set aside it should only be done upon a showing of merits that would entitle Gray to an award of priority and to a patent. Such a patent would run for a period of seventeen years from the date of its issuance and would dominate and control the method and all the devices relating to the telephone for another period of seventeen years. Its effect would be to subject the public to a renewed monopoly,—in all nearly, if not quite, thirty-four years. Such result is in such contravention of the spirit of the statute and so unnatural a consequence, in view of the liberal provisions of the patent system, that it cannot be tolerated, except where the inflexible rules of law and justice compel it. Before an inventor can demand such a result or a patent that would bring about such consequences, he must show himself not only absolutely entitled, but that he has been diligent and persistent in the prosecution of his rights, and that the failure to sooner secure them has been unavoidable and not due to his own mistakes, laches or failure.

It scarcely needs comment or requires suggestion to show that Gray does not bring himself within the requisite conditions for such relief.

If, in addition to the foregoing considerations, there shall be added the further fact that the Bell Telephone Company acquired the equitable ownership of Gray's invention, under the settlement of November 10, 1879, and the transactions prior thereto, and that a patent to Gray would at once inure to that company and enable it or a new combination in this manner to prolong for another full statutory period its monopoly of the invention, there would appear conclusive reasons for refusing the present petition. There is not the slightest evidence before me of the existence of collusion between the Bell Company and Gray and his present associates by which such a result is sought after; but unless the rights of the public shall be strictly guarded and the principles of law properly enforced, such combinations could easily be made and could successfully and unduly extend their monopolies. It is to prevent such consequences that, in many cases, the Office is unwilling to award priority in interference proceedings upon stipulation of parties.

The state of the title as to Gray's invention will be considered further on.

(3.) THE NEWLY DISCOVERED EVIDENCE: BELL'S PIRACY OF GRAY'S INVENTION.

The proposition to be established is that on the 14th of February, 1876, when Gray's caveat and Bell's application were filed, the latter contained no reference to the variable-resistance method (issues B and C), and claim 4 was not in it; that through improper and fraudulent influences of Bell's attorneys at Washington with the examiner in charge of the subject the former were permitted to see the caveat, and thereupon surreptitiously and fraudulently withdrew Bell's specification, rewrote it, incorporating the portion now found relating to the variable resistance and the new claim 4, and substituted the amended and unverified specification for the old. This, if done at all, must have been done before the 19th of February, for the official letter of that date, addressed to both Gray and Bell advising them of the interfering matter, shows conclusively that the suspected matter of the specification was in it at that date.

There is no claim or pretence that Bell received his ideas from Gray in any other way or by any other means than by this alleged fraud of stealing them from the caveat. Indeed the charge does not connect Bell personally with the matter, for it is conclusively shown that Bell was not at Washington during the period between February 14 and February 19, 1876, nor was he in any manner cognizant of the alleged alteration at the time. The theory presented makes it necessary that the fraudulent alteration should have been made by Bell's attorneys at Washington upon their own responsibility and without the authority or consent of their client.

The evidence of this alleged fraud is the "newly-discovered" evidence relied upon by Gray as one of the grounds for setting aside the award of priority in these interferences. It consists of certain evidence—the testimony of Bell himself taken in the People's case, so-called.

In March, 1876, Bell had written Gray: "My specification had been prepared months before it was filed and a copy had been taken to England by a friend." This was George Brown, of Toronto, whom Bell had interested in his inventions in the fall of 1875. In his testimony in the Dowd case Bell had produced the original rough draft of the specification in seven sheets. He testified that he began to work upon the specification in September, 1875, in Canada. He had searched for other drafts of his specification made in the course of preparing his application, but was unable to find them. This was in July, 1879, when he was giving his deposition. He says the seven sheets of the original draft then produced do not read successively, and were

"the mere remains of my first attempt to put into correct language the ideas embodied in my specification. Some passages are written in pencil, others in ink, and many of them are so disfigured by the corrections, etc., that it is difficult in some cases now to read them."

He further says these original drafts are by no means all he made in preparing the specification for his application. He also states that he had concluded arrangements with Mr. George Brown to have the specification filed simultaneously in England and the United States, and the application was not filed here until February 14, 1876, because he was waiting for a cablegram from England. While he does not specifically state that he gave Brown a copy of his specification, his testimony inferentially makes it clear that he did, for he produces a sketch which he placed in Brown's hands before the latter went to England which was handed back to Bell in 1878. But in the cross examination Bell was not asked to produce that copy which he gave Mr. George Brown, nor to state its contents, or whether it contained anything relating to the variable resistance. The original first draft then produced did not contain any reference to it, and as this was one of the import-

ant facts involved the most natural inquiry would have been to ask Bell about it.

When the newly-discovered evidence now relied upon comes to be considered, there can be no doubt that, had he been asked by Gray, or anyone in the Dowd suit, Bell would have replied that the George Brown copy of the specification did not contain claim 4, or any reference to the variable resistance, and would have given substantially the same statement now relied upon, though he might not at that time have been able to produce the copy.

The evidence in the Dowd case was closed in September, 1879.

In the case of The People's Telephone Company *v.* The American Bell Telephone Company, Mr. Bell aga in testified at great length. His deposition was taken in March, 1883, pending the decision of the Examiner of Interferences, whose decision was announced in July following. While Gray was not a party to this suit, he must have been interested in it and cognizant of the progress made therein.

At this time Bell was able to produce some additional memoranda, letters, etc., and among other things he produced the George Brown copy of Bell's specification which the latter had taken to England with the view of taking out the English patent, and which he had returned to Bell in 1878. It is this evidence of Bell relating to the George Brown copy which is relied upon as being new, important and relevant. It is stated substantially as follows:

In his decision (p. 320) the Examiner of Interferences calls attention to

"certain suspicious circumstances attending the production and development by Bell of the liquid-resistance or water telephone, that demand attention. There is an entire and absolute absence of evidence tending to prove that at the time or prior to the filing of his application of February 14, 1876, he had conceived, disclosed, experimented upon or tested, or even contemplated so doing, any form or system of articulating telephones other than magneto, as disclosed in fig 7 of his patent, with the single possible exception of the abandoned and discarded idea of the vibrating wire."

In September, 1875, while in Canada, Bell began the preparation of the specification for his patent and continued it in Boston during the early part of October following. In the Dowd case he produced some rough drafts of his earliest efforts, which were mere fragmentary remains of his first attempt. His specification was prepared subsequently for Mr. Hubbard to take to Washington and have examined by their attorney, Pollok. In January, 1876, Hubbard wrote to Bell:

"I have been over your specification with Mr. Pollok. He is very much pleased with it, and says he does not think it will require any alteration."

A fair copy of the specification was received from Mr. Pollok on the nineteenth or twentieth day of January, 1876, as shown by a letter addressed to Mr. Bell, under date of January 18, 1876:

In his preliminary statement Bell says:

"I completed the specification for my American patent early in January, and sent it to Mr. Hubbard in Washington to be examined by Mr. Pollok. I am not able to fix the date when I sent it: but on the 18th of January I received a letter from Mr. Hubbard expressing his satisfaction with it, and it must have been returned to me then or immediately after, as I made oath to it in Boston on the 20th of January, 1876, and sent it back to Mr. Hubbard. The reason why it was not filed immediately was that it was deemed important that I should meet Mr Pollok and go over it with care. We met in New York shortly after and spent a day, January 25, 1876, in considering the specification. No change whatever was made in it, and Mr. Pollok took it back with him and filed it in the Patent Office."

Hubbard testifies:

"I saw the specification of the speaking telephone in October, 1875. I believe it was substantially like the one for which the letters patent were issued, though several changes were made in it subsequent to my first seeing it. I believe I took it with me to Washington on the 1st of December, 1875. I showed it to Mr. Pollok, brought it back with me on leaving Washington, December 14 or 15: then took it with me on my return to Washington, which was, I think, on the 10th of January, 1876; showed it again to Mr. Pollok, then I returned it to Mr. Bell for his signature and oath."

On the 28th of September, 1875, Bell wrote from Toronto to Hubbard that he was about arranging with his friend, Hon. George Brown, ex-premier of Canada, to become interested in the subject of the invention. On the 29th of December, 1875, a contract was made between Bell, George Brown and J. Gordon Brown, in Toronto, by which Bell agreed to assign them a fourth interest in all his "patents and inventions that are now or may be hereafter taken out in any other parts of the world, except the United States of America," and on the same day received a memorandum from the Browns agreeing to pay him, Bell, twenty-five dollars apiece per month while perfecting his inventions in telegraphy and preparing the necessary specifications for taking out patents under their agreement of that date.

Hubbard also testifies:

"I met Mr. Bell in New York about January 25, at his request to meet Mr George Brown, of Toronto. We met Mr. Brown, and he agreed to take out letters patent in Great Britain. Mr. Bell gave me his copy of the specification, which I was to take under a promise which he exacted from me that it should not be filed at Washington until Mr. Brown should have filed it in England. He did not hear from Mr. Brown as he expected and finally wrote to me that if he did not hear by a certain day that I might file it. I strenuously objected to the least delay, but it was of no avail, as he wished to have it taken out in his native country, that he might there have the benefit of what he believed to be a great invention.

All the foregoing testimony was given in the Dowd case; now follows the "new testimony," which is found in the People's record:

"*Int.* 567. About when did Mr. George Brown go to England?

"*Ans.* About the last week in January, 1876.

"*Int.* 568. Did he take with him a specification furnished by you, corresponding to the specification of your patent of March 7, 1876?

"*Ans.* He did.

"*Int.* 569. Please look at the paper now shown you, and state whether it is the specification which you furnished to Mr. George Brown?

"*Ans.* It is.

[*Complainant's counsel puts a copy of the paper in evidence to be marked "Complainant's Exhibit George Brown Specification."*]

"*Int.* 570. How long before Mr. George Brown sailed for England did you deliver this paper to him?

"*Ans.* I only know that it was handed to him between the date of the agreement, December 29, 1875, and the time he sailed, the latter part of January, 1876.

"*Int.* 571. When was this paper written?

"*Ans.* In October, 1875.

"*Int.* 572. I observe that it is headed 'United States Patent Office,' from which I infer that this particular paper was originally prepared for your American specification and not for the purpose of being handed to Mr. George Brown; what is the fact about that?

"*Ans.* Certainly, that is the fact.

"*Int.* 573. Did you at or about the time when you handed this paper to Mr. George Brown also give to him descriptions of your other electrical inventions patented and unpatented?

"*Ans.* Yes.

"*Int.* 576. In the Exhibit George Brown specification there are some alterations made by drawing a pen through words or phrases, and interlining others in place of them; what is your recollection as to when these changes were made?

"*Ans.* I have not any clear recollection of the time when these changes were made, excepting that they were made before the specification was given to Mr. Brown.

MARCH 12, 1883.

"*Int.* 585. You have told me this morning that you wanted to make some addition to your answer to Int. 571. Please do so.

"*Ans.* Yes. I desire to state that, though from the language used in this paper I know that it is a copy of the specification as I wrote it in October, 1875, I cannot be perfectly certain that the copy was itself made in October, 1875, although it is my belief that it was. It was made as a fair copy, not in my handwriting. The interlineations and corrections are in my handwriting.

"*Int.* 586. I observe that the fifteen sheets of which it is composed are numbered consecutively, and each of them bears at the top the initials 'G. B.'; are those initials Mr. George Brown's handwriting?

"*Ans.* They are; I saw him write them.

"*Int.* 587. The last sheet, which happens to be the sheet of drawings, contains on the back this indorsement: 'These papers were received by me from Prof. Alex. G. Bell in the winter of 1875-6, shortly before I left for England. I can fix the exact date by reference to my books and papers, but have not them at hand now. George Brown, Toronto, 12 November, 1878.' In whose handwriting is that?

"*Ans.* In the handwriting of Mr. George Brown. I saw him write it.

"*Cross-Int.* 621. On the papers which you gave to George Brown, preparatory to his going to England, I find indorsed the words, 'November 12, 1878'; how happened that?

"*Ans.* I had just returned from Europe at that time, and understanding from Mr. Watson, who met me at Quebec, that interferences were arising in the Patent Office, I thought it might be important to obtain from Mr. Brown whatever papers he might have. We therefore called on Mr. Brown in Toronto, on the 12th of November, and at my request Mr. Brown indorsed the papers and gave them to Mr. Watson."

The argument which is founded upon this new evidence naturally connects itself with the history of Gray's caveat, and insists that the procedure in the Patent Office in changing its practice with reference to the dates on which caveats are filed, and holding that Gray's caveat had not been filed prior to Bell's application,

the failure to declare an interference and hold Bell's application until Gray could file one, the speed with which Bell obtained his patent, and the circumstances disclosed by this evidence in connection with the evidence in the Dowd suit, establish the fact that when Bell's application was filed it did not contain claim 4 or any reference to the variable-resistance matter.

It is insisted by Gray's counsel that in pursuance of the contract made by Bell with Brown, December 29, 1875, in order to obtain patents in England, Bell handed him after December 29, 1875, a copy of the specification which had been prepared to take to England to be used there; that Brown met Bell, Pollok and Hubbard on the 25th of January, 1876, in New York, when he agreed to take out a patent in England. This was done to have the applications filed simultaneously in England and in the United States, the intention being that Bell should arrange to have both filed simultaneously; and that as George Brown sailed for England the last week in January, he must have left after January 25 and before February 1, 1876. It is further urged that Brown filed no application for a patent in England upon the specification he took there, and it was not until the 9th of December, 1876, that the application was made for a patent in England by Bell, in the provisional specification of which appears the description of a liquid transmitting device.

It is concluded by counsel:

"There can be no doubt, in view of this evidence, that the specification which George Brown took to England in January, after the 25th, 1876, was a copy of the specification sworn to by Bell five days before, on the 20th of January of the same year; but this copy taken by Brown *does not contain the portion of the description regarding the variable-resistance appliances found in the present Bell specification in the Patent Office*. It is impossible to believe that if Bell had thought of these variable-resistance devices prior to Brown's going to Europe, he would have omitted to describe them in the specification which Brown took there to file simultaneously with the application in this country."

I think the argument has been fairly stated and as strongly as made by the counsel, and it will be seen that the entire force of the argument resides in the proposition that the Brown specification, which had been given to him by Bell, was the exact copy of the specification sworn to Bell on January 20, and filed in the Patent Office February 14, 1876.

The George Brown specification is headed "United States Patent Office," and Bell says it was prepared for the American specification, which shows quite conclusively it was prepared before he had made any definite arrangement with Brown. Bell testifies that the paper was written in October, 1875; that is, that it is a copy of a specification written by him in October, 1875, and while not certain that it was made (as a copy) in October, it is his belief that it was. Bell further testifies that the original drafts produced in the Dowd suit were by no means all the specifications he prepared between September, 1875, and January 20, 1876; so that it is reasonably established that Bell was industriously at work preparing, amending, rewriting, and improving his specifications between those dates. It is clear of course that the American specification was completed about January 10, 1876, and remained unchanged until filed February 14.

Now the argument for Gray concedes that Bell had invented the magneto undulatory telephone, and described it both in the original drafts and in the George Brown specification; for it clearly appears in both. In the latter Bell distinctly asserts that he does not limit himself to any particular mode of producing the electrical undulations. and attempts to broaden his description so as to include others. He says in the George Brown specification:

"There are *many other ways* of producing undulatory currents of electricity, but all of them depend for effect upon the vibration or motion of bodies capable of inductive action. A few of the methods that may be employed I shall here specify,"

He then adds four illustrations of known methods, but does not include the variable resistance. In the statement that all of them depend upon inductive action he was mistaken, for the liquid-resistance mode was then known.

Whether Mr. Bell was sufficiently skilled in patent law to know the importance of embracing in his specification all known methods of producing variations or undulations in the electric current is not shown, but the above quotation indicates that he was, and that he was attempting to specify them. Certainly any one possessing such knowledge would have embraced all *known* methods. The situation was this: Bell had made the discovery, which depended upon the vibratory or undulatory current. This called to its aid and dominated all known methods of producing those undulations. Any one would properly desire to introduce into his specification and cover all the methods. In preparing his specification in October, 1875, Bell evidently tried to do this, and incorporated four methods, but omitted the fifth, the liquid resistance method. But this was a well-known method, just as well known as the others. Bell invented no methods of producing variations in the current; he only applied what were already known. The liquid-resistance mode was then as well known as the other methods which Bell described in his George Brown specification. It required no invention to apply it, for the use of diaphragm was then so well known that the attachment of a diaphragm to the wire which was to be vibrated in the liquid could have been made by any ordinary mechanic. It was fully suggested in the *lover's telegraph*, where the vibrations of the diaphragm operated longitudinally on the string. Why, then, did not Bell introduce this liquid-resistance method into his October specification? Possibly because at that date he may not have known of the liquid-resistance method, or, if he did, it did not occur to him at the time. Where then, could Bell learn that? Is there no source from which he could have derived this knowledge prior to filing his application, unless he acquired it through Gray's caveat? Must he have thus acquired it from Gray's caveat and then have fraudulently incorporated it in his application? Assuredly not. The information existed in books, and was matter of common knowledge. It could be obtained from associates, those with whom he conversed. It is probable that Bell possessed the knowledge previously, but it did not occur to him when preparing the first drafts of his specification; the magneto undulatory mode, depending upon induction, through which the invention had been made, being at that time uppermost in his mind.

A comparison of the original draft, the George Brown draft, with the final specification shows that they present internal evidence of progression toward completeness, and that they were not written at the same time, nor can either be a copy of the other.

A complete *alibi* is shown for Bell. If the fraudulent interpolation was made, it must have been made between the 15th and 19th of February by his attorneys without his knowledge or consent. There is not a scintilla of evidence that they had any possible knowledge of the existence of the caveat until after the 19th of February. The Bell specification is word for word the same as his patent. I have personally examined the specification, and find that it is written upon both sides of the paper in a clear fair hand, so continuously from page to page that if any such change or alteration was made, the entire specification must have been abstracted and a new one restored in place of it.

It is incredible that attorneys of intelligence and standing would, without their client's knowledge, change a specification which had been prepared with such unusual care, and thus imperil his rights in such a novel and valuable invention. They could not know that the additional matter could be properly added, and consequently the act might be condemned by their client, not only as prejudicial, but as an infamous fraud. If the alteration was made by the attorneys who had stolen the idea from the caveat, it would have introduced the identical invention found there, for they were neither electricians nor experts; but the invention introduced was a different one, and shows that whoever wrote the passage understood thoroughly the secret of the telephone, which Gray did not. Gray used a liquid of *high* resistance. This suspected passage in Bell's specification called for a liquid of *low* resistance. Bell had been in pursuit of the delicate sound waves that constitute *quality*. This Gray did not understand when he prepared his caveat, for, as shown heretofore, Gray was unable to explain the operation and still adhered to the multiple-tone idea. In other words, the suspected passage shows a full appreciation of the invention which is not found in the caveat, and which neither Gray nor the attorneys of Bell possessed sufficiently to have prepared it.

The charge in the practice as to caveats which held a day *punctum temporis*, was made by the Commissioner upon consideration, and not by the suspected examiner, whose action in the matter had been adverse to Bell. There can be no question that Commissioner Spear's action was correct. (Louisville *v.* The Bank, 104 U. S. 469.) The fact that the Bell application was filed in the Office earlier in the day than the Gray caveat was determined by an investigation instituted by the Commissioner at the time when it was susceptible of investigation. Both Bell's and Gray's attorneys knew just when the respective papers came into the Office. Attèntion has already been called to the fact that when the commissioner withdrew his notices as to the caveat, Gray could have had an investigation, but did not, nor did he arrest the issuance of Bell's patent when he might have done so by filing his own application. But he did neither, and no doubt it was because his attorneys were entirely satisfied that the Bell application preceded the caveat "a couple of hours." Notwithstanding that this subject was urged upon the attention of the Supreme Court in the telephone cases, that court appears to have disposed of it in a single sentence, "Bell's application was filed February 14, 1876, and *afterward*, during the *same day*, Elisha Gray filed a caveat," etc. The order of filing was thus judicially declared, and there is no intimation that having been filed on the "same day," one was not filed earlier than the later, or that the caveat had not been given its proper status in the Patent Office.

The Bell patent issued very promptly. It met with neither anticipating reference nor with interference. It was a new art, for the transmission telegraphically of articulate speech, and so went speedily to patent because it went unchallenged.

In concluding this subject of the alleged fraudulent alteration of Bell's specification, it is proper to observe that this very question, based upon this identical new evidence, was presented to the Supreme Court in Telephone cases, and was fully considered and passed upon. I might have contented myself merely with citing the portions of the opinion relating to it, but I felt it necessary to dwell upon some considerations not mentioned there. One extract from the opinion will be sufficient :

"On the 25th of January, 1876, Bell met Brown, who was then on his way to England, in New York. It is now assumed that the paper which Brown took to England was handed him then, and because the variable-resistance method and the fourth claim were not in that, it is argued that they could not have been in the American specification at that time. But no one has said when the paper was actually handed to Brown. Bell says he cannot tell, but that it must have been after he had made his contract with Brown on the 29th of December. As the American specification was signed and sworn to five days before the interview with Brown on the 25th of January, and the paper of Brown differs from it in so many particulars besides that now in question, it would seem to be clear that the paper was a copy of some former draft which Bell had made—possibly one taken to Canada in December, and not of that which was perfected afterwards. As the specification which had been prepared and sworn to was a fair copy, without erasures or interlineations, the fact that the paper handed Brown was not a fair copy would imply that it was not intended to be a exact transcript of the other. At any rate, the bare fact that the difference exists under such circumstances is not sufficient to brand Bell and his attorneys and the officers of the Patent Office with that infamy which the made charges against them imply. We, therefore, have no hesitation in rejecting the argument. The variable-resistance method is introduced only as showing another mode of creating electrical undulations. That Bell had had his mind upon the effect of such a method is conclusively established by a letter which he addressed to Mr. Hubbard on the 4th of May, 1875, and which is found in the Dowd record, introduced into the Overland case by stipulation. Its insertion in his final draft of his specification is another proof of the care with which his work had been done."

I am of opinion that this so-called new evidence is really not such. It does not appear but that all the facts sought to be established by it, viz., that the George Brown specification did not contain the variable-resistance clause, could have been ascertained by asking for it in the Dowd deposition. Neither is it shown that by the use of ordinary diligence Gray could not have discovered this evidence in the People's case years before he did. The difficulty is that he has been acting under the belief that he did not own the inventions, and that Bell was the prior inventor and has allowed years of inaction to follow. Under these circumstances he cannot allege diligence or be excused for negligence. Especially will not a court excuse his negligence and delay when the causes assigned are not established, and it accepts his former opinion as to ownership and priority to have been correct.

But even if satisfied that the evidence was newly discovered and that Gray could not have earlier discovered it by the exercise of diligence, it would still be unavailing, for the reason that, giving it all the force and effect asked for it, it could not change the result or throw any doubt upon the correctness of the former decision.

As to issue C, it is insisted by Gray that the decision in the interferences was erroneous because Bell does not show or describe a liquid transmitter in his patent, and that consequently there should not have been an interference nor an award of priority to Bell. Some justification for the suggestion may be found in the decision of the Examiner of Interferences, who says: "While no such instruments are found described in Bell's patent, his proof as to Exhibit 41, its description, use and exhibition, are considered as amply sufficient to defeat the claims of Gray and Edison, founded upon the facts appearing in the record, at the same time anticipating Richmond's record date of August 24, 1877."

But evidently this view is a misapprehension of what the Examiner of Interferences means. He does not mean that a liquid transmitter is not shown, but that its specific contruction was not shown in Bell's patent. As heretofore stated by me, the liquid-resistance method and means of applying it by moving the wire by hand or otherwise were well known, as was also the use of a membrane or diaphragm, so that any one skilled in the art would know from Bell's patent how to construct such a transmitter. It was therefore deemed to be shown in that patent. The examiner declaring the interference must have so held, otherwise he would not have made Bell a party to issue C. Not only this, but Gray made no motion to dissolve the interference, and I have no doubt as to the correctness of the action of the Office in either declaring or deciding the issue. What has been said about issues A and B is conclusive as to this.

GRAY'S TITLE.

The Commissioner of Patents has no equitable jurisdiction over the rights of parties claiming under assignments and grants of inventions and patents. He cannot set aside or vacate such instruments, nor can he recognize equitable rights growing out of transactions between inventors and applicants and other parties. While he is authorized to recognize formal legal assignments, and, when they have been filed in the Patent Office before patent issues, may give the assignee control of the management and prosecution of an application and direct the patent to issue in the name of the assignee, yet he cannot recognize equitable rights under executory or other equitable contracts. (*Ex-parte* Edison, C. D. 1875, 42.) But when a party to an interference which has been determined adversely to him asks a rehearing and bases such request upon the allegation that during the trial he was laboring under the supposition that he had parted with the ownership of his inventions, and that in consequence, although he remained a party, was active in securing and giving testimony, the parties to whom he supposed he had transferred were the actual managers of the case; that in consequence—"I had no counsel, I was not a litigant. The whole apparent controversy was, as I now believe, collusive, carried on with an appearance of an array of opposing counsel,"—the question of ownership is made material, and it is competent for the Commissioner to examine it in order to know how to exercise his discretion intelligently. A party cannot make the question of ownership or non-ownership a material ground of the relief sought and at the same time deny the power of the tribunal to consider and pass upon it.

It is unnecessary to again refer at length to the transaction between Gray and White and the American Speaking Telephone Company and its associates, resulting in the settlement of November 10, 1879. It is evident that that agreement and the transfer of telephone inventions were made under the belief that it included Gray's inventions, and but for such belief it would not have been made. Gray so understood the agreement, and was a beneficiary under it. The American Speaking Telephone Company had previously put out large numbers of Gray's telephones as its own property. In the settlement of November 10, 1879, it was expressly stipulated that the inventions of Gray

became the property of the Bell Company. That all this was done with the full knowledge of Gray is not controverted. With this knowledge, and acting under this belief, Gray has allowed seven years to pass, knowing that third parties were also acting in the same belief and making investments upon the strength of the transactions, and that the interests of the general public were directly involved. If Gray can now repudiate these transactions and assert his ownership, it would constitute *pro tanto* a rescission of the agreement of November 10, 1879, though it would be totally impossible to restore any of the parties to their original situation.

Under these circumstances the authorities relied upon as to the estoppel seem conclusive. The Bell Company is certainly the equitable if not the legal owner of Gray's telephone inventions.

Bronson's Exe'r *v.* Chappell, 12 Wall. 681.
Morgan *v.* R. R. Co., 96 U. S. 716.
Bank of U. S. *v.* Lee, 13 Pet. 107.
Dickerson *v.* Colgrove, 100 U. S. 578.
Baker *v.* Humphrey, 101 U. S. 494.
Close *v.* Glenwood Cemetery, 107 U. S. 466.

It follows, therefore, that Gray was not mistaken in his original opinion that the Bell Company had become the owner of his inventions, also that his original belief that Bell was the first original independent inventor and had not pirated any invention from his caveat was also correct, and that all the alleged grounds for reopening these interferences and granting a new trial must fail.

ISSUE G.

"A telephonic receiver consisting of the combination in an electric circuit of a magnet and a diaphragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality."

This issue relates to the receiver. All that has been said about the title of Gray's inventions involved in the other issues is equally pertinent here ; that the conclusion is much strengthened by transactions not yet referred to.

Gray took out patent No. 165,095 on July 27, 1874. This covered what is commonly called the blacking-box receiver. It has been formally transferred with other of Gray's inventions by mesne assignments, until it came to belong to the Harmonic Company. It was reissued to the latter company. In 1880 the Harmonic Company assigned it to the American Speaking Telephone Company, so far as it related to speaking telephones, but not including its use for harmonic telegraphic purposes. This patent, subject to this limitation, subsequently went to the Bell Company, under the contract of November 10, 1879. Gray obtained reissues of the patent, with claims of which this is one :

"The diaphragm or disk of metal capable of responding to all kinds of tones vibrating in unison with the electro-magnet included in the electric circuit, substantially as set forth."

In his testimony in the Dowd case and in his preliminary statement in the interferences Gray repeatedly stated that he had made the inventions embraced in issues G, I, C and E in the year 1874, and that they were covered in his patent No. 166,095, which, as already explained, has been assigned, then reissued to the Harmonic Company, and then, as to the use of said inventions as telephones, transferred to the Bell Company. Thus, according to Gray's description of the inventions and his claim for the same, there is a technical formal transfer of them and he is not the owner of them. His patent No. 166,095, and the reissue, would bar his present claim, and even though he could take out a patent it would at once become the property of the Bell Company.

While it is true that patent No. 166,095 and the reissue of the same cover a receiver, "the diaphragm or disk capable of responding to all kinds of tones vibrating in unison with the electro-magnet," etc., yet the present contention of Gray, in issue G, is that he had invented a receiver that would thus respond to *tones*, and he believed and also expressed the opinion that such a receiver was capable of responding to quality and of reproducing articulate speech, if a transmitter could be found; and that therefore his *tone* receiver was a *quality* receiver, the latter capacity of responding to quality arising only from a new or additional use of which the receiver was originally and at all times capable.

It is clear that if this be true, still the invention, whatever it was and however capable, has been assigned, and as a telephone receiver is now the property of the Bell Telephone Company.

The argument urged with so much force by Gray, that after one of the parties has acquired all the interests in the controversy there should be no further contest, is certainly applicable here where the objection is presented and urged. Especially is it true that under such circumstances a defeated party who has parted with all his interest cannot be allowed to reopen an adjudication in order to retry a matter in which he can have no interest. The discretion of the Commissioner cannot properly be called in aid of a request to reopen and re-try these interferences simply to gratify the personal pride or reputation of one of the parties. If the title to Gray's invention is vested in the Bell Company, and that company is content with the adjudication, no one else can properly complain.

Referring now to the merits of this issue G, its proper construction must be determined. As heretofore shown in the statement of the facts, and extracts from the decisions, the Examiner of Interferences held the issue to mean—

"a receiver containing an electro-magnet and a diaphragm supported and arranged in close proximity thereto, and adapted to respond to variations in the electric current passing through the coils of the magnet, when used in connection or combination with a transmitter adapted to create sound-producing fluctuations in the electric current, *whether said electrical variations, waves, pulsations, or undulations represent or are derived from sound waves or mechanical vibrations.*"

In other words, he held in effect that the issue covered a receiver which was capable of responding to and reproducing the tones in pitch of sounds, possessing the capability, when operated on by a proper transmitter, of responding to and reproducing the more delicate variations that constitute quality; that it was merely a new use when a receiver which had responded to a transmitter of tone or pitch was placed in connection or combination with a transmitter capable of transmitting quality or articulate speech. I have already called attention to the fact that the potential possibility of a disk held in close proximity to an electro-magnet was old. It existed in a rudimentary state in the Morse telegraph, and has not only been described in such publications as those of Bourseul and others, but it was long known that the armature or diaphragm would respond to the increased or decreased energy of the electro-magnet in connection with the electric circuit. Not only this, but it was believed and so expressed by scientific men and published in publications, that if the circuit could be controlled by some proper device or transmitter, articulate speech conld be transmitted and reproduced by the receiving disk. But between these speculations and the discoveries which realized them, there lay long regions of invention.

When it is recalled to mind how near Reis came to discovering the telephone,—what a slight apparent line lies between his transmitter and the microphone transmitter of Berliner so near, indeed, that the former sometimes, without the knowledge of its inventor, may have operated on the principle of the microphone and sent across the circuit a stray word or syllable, and, in the light of more recent knowledge, can be adjusted to act as a microphone,—we can appreciate how near men may approach to great discoveries without finding them, and what distances in invention sometimes separate necessities or speculations that are almost contiguous.

If it can be said that there is no invention or patentable difference between a receiver which, by reason of want of skill and knowledge, can only reproduce tones, and one which, by the invention of a proper transmitter, can reproduce quality, and that the new relation or adjustment of the latter is only a new use of the former, then we may go back and say of the former that there is no patentable difference between it and the Morse receiver or that described by Bourseul and others, and that its use as a tone receiver is only a new use : for the old diaphragm placed in close proximity to the electro-magnet possessed all the qualities and potentialities of the Bell or Gray diaphragm ; but between these stages of development there was invention. As well might it be said that the reversing of the magneto receiver and using it as a transmitter was merely a new use of it and disclosed no invention. In my judgment no broad claim for a magneto receiver can be main-

tained. It must be limited to its relation to the transmitter with which it is combined; for between such a combination that will transmit and reproduce pitch alone and one that will do this and also transmit quality or articulate speech, there is great invention. The history of the subject, the vain and failing efforts of scientific and learned men of genius for years, demonstrate this, no less than the philosophical and scientific principles involved.

If, however, issue G, could properly bear the construction, given it by the Examiner of Interferences, it will not avail Gray; for if he were allowed to take dates of invention for a receiver of tone or pitch, so should also the other parties to the interference. Edison and McDonough had made inventions of receivers which would reproduce pitch, and of course their tone receivers possessed the same capabilities as to new uses, quality, etc. It is unnecessary to dwell at any length upon the evidence relating to the efforts of these various parties, as the construction of the issue cannot be maintained and was reversed by the Examiners-in-Chief. It is sufficient to say that it is doubtful if Gray ever conceived the invention prior to his caveat; but admitting that he did, even earlier than Bell or Mc Donough, he never reduced it to practice or gave the public the benefit of it, nor did he prosecute it diligently by efforts to reduce it to practice, or by filing an application. Consequently it is impossible for him, upon his own statement of facts, to overcome Bell's record date.

The Examiner of Interferences awarded priority to McDonough, holding that he had first conceived the invention in May, 1875, and had been diligent in prosecuting it up to the filing of his application, April 10, 1876. This decision was subsequently reversed by the Examiners-in-Chief, who awarded priority to Bell and whose decision was affirmed by Commissioner Butterworth; but this need not be considered further here, as it relates to McDonough's case, between whom and Bell the controversy remains. In any event, Gray cannot succeed in this issue.

The proper construction given the issue by the Examiners-in-Chief and the commissioner does not affect Gray's status with reference to it. If priority could not be awarded to him under the former construction it could not be under the latter, for under the latter, as already shown, his earliest date is that of his caveat, which fails to overcome Bell's record date.

Upon these considerations, Gray's petition to set aside the orders, etc., in the interferences, and open up the case anew, must be denied.

MC DONOUGH'S CASE.

McDonough's application was filed April 10, 1876, for a teleloge, or far speaker. He did not claim to have invented a method of transmitting articulate speech.

"The object of my invention is to provide a *means* for transmitting articulate sounds from one place to another through the medium of electricity, and it consists in the combination with an electrical battery, circuit wires, armature, magnet and circuit-breaker, of a transmitting and receiving membrane or sounding apparatus. . . . My invention also consists in the novel construction of the circuit breaker, as hereinafter more fully described."

His original claims were as follows:

"1. The combination with the battery, circuit wires magnet, armature and circuit-breaker of the transmitting membrane A and receiving membrane F, substantially as and for the purpose specified.

"2. The combination with the plates C C of the circuit-breaker D′, whereby the circuit is alternately opened and closed by the vibrations of the membrane A, substantially as specified.

"3. The combination of the bolt D and adjusting nut E of the circuit-breaker D′, substantially as and for the purpose specified."

April 28, 1876, his claims were rejected upon reference to the "old Reis telephone." His claim to the receiver was rejected upon reference to Bell's patent No. 174,465. March 4, 1878, McDonough amended his specification, adding, among other things:

"The breaking of contact may be rendered more abrupt and the contact rendered more perfect by a drop of water or oil."

He also struck out all the claims, and inserted the following:

"The combination with the membrane A, plates C C, the circuit-breaker D′, of the bolt D and adjusting nut E, *for confining the vibrations* of the membrane againt the circuit-breaker, substantially as specified."

At the date this application was filed the principle of the microphone had not been discovered or applied; but at the tim e this amendment was filed it had been and was known. The change by the amendment whereby the nut E was given what seemed a new function, not originally contemplated, "for *confining* the vibrations of the membrane against the circuit breaker," was regarded by the office as a departure from the original invention and as an attempt to adopt or incorporate the new feature of the microphone.

Accordingly, on March 8, 1878, the Office replied as follows:

"The amended claim filed March 4, it is thought may be allowed. The matter introduced at the end of the specification by this amendment is, however, held to be new matter as it describes modifications nowhere adverted to or shown in the application as originally filed. This matter should consequently be erased."

This claim involved nothing but the peculiar construction of the *circuit-breaker*, and thus left the application without any claim to a receiver or other element in the teleloge or telephone. From that date until the present time no other claim has been presented.

On March 26, 1878, the interferences were declared and notices issued to the parties. Under the practice then and ever since existing, McDonough could not have been put into interference with Bell, and no issue could have been formulated between their inventions, for the reason that McDonough claimed nothing shown or claimed in Bell's patent. He was brought into the interference in consequence of the fact that applicants whose cases were filed later than his (Edison, Gray and others) made claim to elements in the telephone which he showed but did not claim. In other words, when rejected upon reference to Reis and to Bell's patent, McDonough submitted to the rejection and voluntarily eliminated the claims, much as a suitor in court dismisses certain counts in his declaration; but inasmuch as his application still showed a so-called telephone, he was put into interference with Gray and others, so as to compel them to establish that they made their inventions earlier than that shown by McDonough. His position was, therefore, one of obstruction to Gray and other later applicants, but not to Bell, whose application was earliest in the Office. It would seem, therefore, a natural and necessary consequence, inasmuch as there could be no interference between McDonough and Bell alone, that when Gray and the later applicants were defeated and taken out of the interferences, there could be left no interference or contest between the former two. Especially would this seem to be true in view of the fact that McDonough had expressly avoided an interference with Bell by dismissing his claims. Not only did he do this, but afterward, August 20, 1879, he wrote the Office among other things:

"I should like to ask a question, if not improper. Having fully *described* in my application, filed April 10, 1876, a *speaking* telephone, am I not fully concerned in the case of interference A? By answering you will oblige, etc."

He was informed that he could not properly be a party in case A, and that if he thought otherwise he should make proper motion, etc., but he took no action whatever.

McDonough's preliminary statement, filed May 1, 1879, is as follows:

"James W. McDonough, being duly sworn, deposes and says that he is one of the parties to the above-entitled interference; that he conceived the idea of a *telephonic receiver* consisting of the combination in an electric circuit of a magnet, a diaphragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced as to pitch and quality, and also constructed a practical instrument as early as 31st of December, 1867; that subsequently, on the 26th of August, 1871, this deponent made drawings of a speaking telephone embodying his said ideas, and that thereafter, on the thirtieth day of June, 1875, this deponent reduced the same to practice by constructing and operating a speaking telephone, substantially as shown and described in his said application."

It is insisted by McDonough's counsel that this in itself constitutes a claim to a receiver and relieves his case of the difficulty referred to. It will be observed that by the award of priority Gray and all the latter applicants for whom the interferences were declared have been fully disposed of. They are no longer parties, and McDonough is now seeking to reopen the contest as between himself and Bell, when upon his application no such contest could have been originally declared. Nor, under the rules of practice, so long as his present petition stands, can McDonough amend so as to justify such a contest.

I am not prepared to hold that McDonough is barred of this right to petition, in view of the condition of his case. Had he not originally dismissed his claims voluntarily and acquiesced in the rejection at a time when he knew the telephone was going into public use, there probably would have been no question as to his right to amend within a reasonable time so as to claim the receiver; but having voluntarily eliminated his claims, at a time when his alleged receiver was going into public use, and allowed eleven years to elapse without any other effort to amend or file a divisional application including the claim, a very different case is presented. At the date of his preliminary statement the invention had been in public use for over two years, and this, as just stated, with a voluntary cancellation of his claims.

I am not willing to dispose of the petition upon this ground, or hold that, even if McDonough could reopen the interference as to Bell and secure an award of priority, he could not amend; but the situation is suggestive. A patent to McDonough under these circumstances would dominate the entire telephone inventions, as far as now of any commercial value, and it is certainly a serious question whether an applicant who has cancelled his claims and apparently abandoned them, under the circumstances stated, ought to be permitted, after the invention had been introduced and made valuable, to reinstate his claims and receive the benefit of others' enterprise, energy and capital. While it may be said that all through the interferences he has been contending for his receiver, and this was public notice that he had not abandoned it, yet, as already stated, this was done in a controversy with the later applicants.

It is from his application alone that there can be ascertained what an applicant's claims are, and this showed, at least as to Bell and those claiming through him, that McDonough had acquiesced in the references cited in the rejection, Bell being one of them, had cancelled the claims and allowed them to remain so cancelled, and in 1879 had his attention called specifically to the subject of the general interference A, with a statement that he could not be made a party to it.

While it may be that this condition of McDonough's case is not such as to constitute a bar to the relief sought in his petitions, it certainly suggests that his right to the relief should be most convincing before it should be granted.

THE PETITIONS.

The petition signed by counsel as attorneys for the North American Telephone Co., *et al*, is so vague and general that it could not be considered in the civil courts, either as a motion for a rehearing or an assignment of errors. It assigns the following:

First. The interferences were fraudulent and collusive and carried on in the interest of Bell, etc.

This has been fully disposed of in Gray's case, where it more appropriately belongs; McDonough is not in a situation to raise the objection. In interference G there was a contest between himself and the Bell Company as assignee of all the important inventions. It is true that he also had given the Bell Company an executory agreement to transfer his invention to that company, but it was conditional upon securing his patents, so that he still retained the title so as to support his demand for the consideration whenever the condition thereto should be performed. He was a proper and active party. Although much was said in argument about a conspiracy and combination between Bell and others to conduct the interferences in the interest of Bell, the evidence does not support the charges. Indeed, it is impossible to see how McDonough can avail himself of such a charge. It is asserted by implication at least, that the Bell Company undertook or were in some manner under obligation to aid him (McDonough) in the contest to secure his patents; but clearly there is nothing to justify such an idea. In the agreement of November 2, 1880, on on which five thousand dollars was paid McDonough, it is expressly provided:

"This agreement is not to be taken as any manner of admission by either party as to the validity or invalidity of claims made by the respective parties."

This was executed long after the declaration of interferences, after the settlement of the Dowd case, and when McDonough knew well that the respective parties were preparing to establish, if possible, their claims to priority. At that date the Bell Company had become the owner of the important inventions of Edison and others, and had secured a hold upon McDonough by virtue of this contract. However much that company might prefer to secure an award to Bell, it is clear that its status could not be injured by securing as assignee a patent to the person whom the Patent Office should adjudge the prior inventor, for it would then hold both patents. In any event, there is nothing in the statute, the practice, or in reason why the Bell Company as assignee of Edison and other inventors should not contend for such priority as they deemed right and proper; nor is there anything in the relation between McDonough and that company upon which he can found complaint that such course has been pursued by it. He was simply a party to the interference, interested in establishing his own priority. In contested litigations each party necessarily looks after his own case, and cannot complain that the adverse parties do not assist him or do not forego their own interests. Such proceedings are open and public, and before they can be attacked some actual fraud or wrong on the part of the successful party must be shown whereby the right of the losing party has been prejudiced or by which he was prevented from fairly presenting his case.

It is in view of these propositions that McDonough insists that the Dowd record, to which he was not a party, and in which the testimony of witnesses whom he never had opportunity to cross-examine was taken, was stipulated into the interference without his knowledge and consent; but the record shows that this stipulation was made by his own attorney, and that long before the trial of the interferences, and at a time when he could have interposed objection, he was made aware of the fact and was furnished with a copy of the record. At no time did he interpose objection or make any movement to strike the Dowd record out of the case or seek to examine the witnesses. A client is bound by what is done by his attorney in the course of conducting and managing his cause in court. He is presumed to know what is done by his attorney and to authorize it. But here it is shown that McDonough was advised in time to have recovered from the position if there had been anything objectionable or improper in it. It may be, as suggested, that not being a lawyer and relying upon his attorney, he did not personally read and inspect the voluminous record, nor understand what it contained; but this will not avail here. If he is unwilling to be bound by the acts of his attorney, then he must act for himself and cannot plead his own failure as a justification. Especially cannot he do so after trial in support of a motion for a new trial.

As to the difference between the paragraph found in the memorandum of settlement and the formal contract of November 10, 1879, I am not able to perceive that any importance can attach to it. It is immaterial whether in preparing the original draft there was present the idea of submitting the question of interference to the Patent Office or not. If it occurred to the parties afterward, when they came to put the memorandum in formal shape, it was proper to insert it. The interferences had been declared a year before and were pending. It was necessary to dispose of them. Issue G was a seriously-contested matter. The Dowd case was still pending in court. To add to the paragraph the words, "subject to the orders of the courts and the decisions of the Patent Office," was certainly appropriate in view of the situation in which the contracting parties were placed.

The second and third assignments of error relate to the question of priority of invention and the effect of Bell's patent, and will be disposed of hereafter, with the consideration of the merits.

The other petition, signed by McDonough, assigns the following causes for the relief asked, viz., reopening interference G, and granting leave to furnish proofs in regard to operativeness, etc.

First, Error on the part of Commissioner Butterworth in considering certain affidavits of Professors Brackett and Young taken and used in the suit of the Bell Telephone Company *v.* the Overland Telephone Company, but which were not part of the record in the interferences. It appears, however, that these affidavits were read, or parts of them were read, by the respective counsel of McDon-

ough and the Bell Company, without objection from either, so that although not taken regularly or formally in the interference proceeding, they were used therein. Of course, this being so, it cannot be complained of by either party as error.

Second. That the Commissioner decided the interferences with a determination not to decide the issue adversely to Bell. This has been disposed of in the Gray case, where the objection was made that the Commissioner's decision was not a "deliberate" decision. There is nothing to justify the idea or suggestion that the decision was made with any predetermination in either direction.

Third. That having denied, in his decision of January 16, 1885, the motion to reopen the case and remand McDonough's application to the Primary Examiner on the question of operativeness there was error in his final decision in not taking further steps to investigate the operativeness of McDonough's invention; also, in considering the affidavits of Young and Brackett in the Overland case. The decision of Commissioner Montgomery, of March 29, 1887, disposes of this, so far as it relates to operativeness, although I hold that this question inheres in Commissioner Butterworth's final decision and can now be properly urged in McDonough's motion for a rehearing as to that. It will be considered hereinafter, in connection with the merits of the petitions. As to the affidavits of Young and Brackett, that question is disposed of above.

The remaining assignments of error relate to the operativeness of the invention and the merits of McDonough's case, and will be considered under the general subject of

MERITS.

From what has been shown it is clear that McDonough has never claimed to have been the original inventor of the telephone, either the method or the appartus. This appears clearly from his specification in his application and his preliminary statement. In the former he limited his claim to a little device for making and breaking the circuit according to Reis. In the latter he claimed the magneto receiver. He calls himself a mere improver upon Reis's instruments, accepting him as the original inventor. In presenting the petitions under consideration, his counsel, Mr. Hurd, says:

In 1874-5 "there were two classes of applicants before the office; those who recognized Professor Reis as the inventor, and whose efforts and attention were directed exclusively to the development of his instruments and the operation of the methods which he described by which speech might be transmitted. Of these McDonough was probably the most prominent."

So also, Mr. Ingersoll, after stating that the first point in the investigation is whether the evidence absolutely shows that Reis's telephone as invented by him will speak, adds:

"The importance of that is perfectly manifest from the further fact that McDonough claims an improvement on that system, so that the first question is, will the Reis telephone talk? Was it intended to be and is it a speaking telephone?"

It will be remembered that Reis's receiver is what is known as the knitting-needle receiver—a bar of iron within the coil of the circuit wire, and affected by the make and break in the circuit. The only improvement presented by McDonough is to substitute his diaphragm and magnet for this knitting-needle receiver. He had never conceived of the undulatory current or the variable resistance, but accepted and still accepts the make-and-break system of Reis as the foundation of his invention. The Examiner of Interferences, the Examiners-in-Chief and the commissioner have held that articulate speech cannot be transmitted by means of the Reis instruments as made and described by him, and as made and described by McDonough. In other words, it has been and is the settled judgment of the Patent Office that speech cannot be transmitted by any instrument which operates solely by the making and breaking of the circuit according to Reis. This also has been definitely settled with reference to Reis by the Supreme Court of the United States in the Telephone cases.

"But it is needless to quote further from the evidence on this branch of the case. It is not contended that Reis had ever succeeded in actually transmitting speech, but only that his instrument was capable of it if he had known how. He did not know how, and all his experiments in that direction were failures. With the help of Bell's later discoveries in 1875, we now know why he failed. . . .

"We have not had our attention called to a single item of evidence which tends in any way to show that Reis, or any one who wrote about him, had it in his mind that anything else than the intermittent current caused by the opening and closing of the circuit could be used to do what was wanted. No one seems to have thought that there could be another way. All recognized the fact that the 'minor differences in the original vibrations' had not been satisfactorily reproduced, but they attributed it to the imperfect mechanism of the apparatus used, rather than to any fault in the principle on which the operation was made to depend.

"It was left for Bell to discover that the failure was due, not to workmanship, but to the principle which was adopted as the basis of what had to be done. He found that what he called the intermittent current—one caused by alternately opening and closing the circuit—could not be made, under any circumstances, to reproduce the delicate forms of the air vibrations caused by the human voice in articulate speech, but that the true way was to operate on an unbroken current by increasing and diminishing its intensity. This he called a vibratory or undulatory current, not because the current was supposed to actually take that form, but because it expressed with sufficient accuracy his idea of a current which was subjected to gradual changes of intensity exactly analogous to the changes of density in the air occasioned by its vibrations. Such was his discovery, and it was new. Reis never thought of it, and he failed to transmit speech telegraphically. Bell did, and he succeeded. Under such circumstances, it is impossible to hold that what Reis did was an anticipation of the discovery of Bell. To follow Reis is to fail, but to follow Bell is to succeed. The difference between the two is just the difference between failure and success. If Reis had kept on, he might have found out the way to succeed, but he stopped and failed. . . .

"So as to James W. McDonough. We presume that it will not be claimed that he is entitled to more than he asked for in his application for a patent filed April 10, 1876, and there a 'circuit breaker,' so adjusted as to 'break the connection by the vibrations of the membrane,' is made one of the elements of the invention. The Patent Office was clearly right in holding that he had been anticipated by Reis."

The question must now be regarded as finally settled in the Patent Office. The fact that certain patents have been issued to persons *ex-parte* by the Patent Office, whether erroneously or inadvertently, which appear to recognize a different opinion, cannot change a deliberate conclusion thus reached in a contested matter after full consideration.

It must also be recognized as settled, that if an occasional word was ever transmitted by the Reis instrument, the result was due to the fact that the instrument, at the moment it happened, failed to operate in accordance with the principle of its construction; the make and break did not occur; the contact of the electrodes remained, and the instrument secretly and without Reis's knowing the fact operated upon the principle of the microphone, which was not yet discovered. It must also be recognized as settled, that if an instrument constructed according to Reis, and as described by McDonough in his application, can now be made to transmit speech, it must be by means of adjustment of the electrodes, so that it operates, not upon the make-and-break principle as described, but upon that of the microphone, which has been discovered since Reis made his invention.

Now, this distinction is not one of mere theory or speculation, but of principle or knowledge and specific construction of the invention. Under the patent law, invention is not recognized in the mere doing of something new, or the accomplishing of some new result. A new and valuable product may be accidentally discovered and produced, and the discoverer not be able to recall the steps of his process or reproduce the product. There is the first specimen. It is new, concrete, tangible and useful; but there is no invention within the meaning of the patent law. Though the operator has made the product, he does not know how it was made and cannot explain the process to others.

"The accidental effects produced in Daniell's water barometer and in Walther's process for purifying fats and oils preparatory to soap-making are of the same character. They revealed no process for the manufacture of fat acids. If the acids were accidentally and unwittingly produced while the operators were in pursuit of other and different results, without exciting attention, and without its even being known what was done or *how it had been done*, it would be absurd to say that this was an anticipation of Tilghman's discovery."

(Tilghman *v.* Proctor, 102 U. S. 711.)

To constitute invention it is required by the statute that the inventor shall possess knowledge of the very construction of the instrument or means and of its mode of operation, so that he can communicate the same to the world and enable others, pursuing the very directions pointed out, to construct the same instrument

or means, operate it in the manner pointed out, and accomplish the same result. This Reis could not do as to this instrument; for his description of construction and operation was that the electric current must be broken and closed, whereas, to make it transmit speech, the very opposite was required, viz., that the electrodes should remain in contact, so that the microphonic principle of variable resistance could operate. His knowledge was such as would lead the world in directly the opposite direction from that required to produce the desired result, and would show others how not to do it. The true construction and necessary mode of operation remained in the secret arcana of nature until discovered later on. They were not discovered when McDonough filed his application in which, in compliance with the statute, §4888, he attempted—

"a written description of the same (his invention) and of the manner of making, constructing (compounding), and using the same, in such full, clear, concise and exact terms as to enable any person skilled in the art or science to which it appertains or with which it is most nearly connected to make, construct (compound) and use the same; and in case of a machine he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions, etc."

What has been said of Reis is equally true of McDonough. He built upon the palpable make-and-break system. The fatal vice of giving the wrong description and directions is in his application, and he can never depart from what was and is now in it. If his teleloge has ever talked or can now be made to transmit speech, it must be changed in its construction and mode of operation so as to become a microphone; or if by the light of later knowledge and experience the makes and breaks, instead of being palpable and of full amplitude, are rendered inappreciable so that its mode of operation is different, the original invention becomes lost in a newer and later one, which must be presented in a new and later application.

McDonough presents a number of affidavits and statements of scientific persons who testify to having been able to make the Reis telephone transmit articulate speech. He has also presented evidence that tends to show that his original instruments did so; but did they do so *in the mode pointed out* by Reis; or by McDonough in his application? These witnesses do not so testify. Most of them simply undertook to make a telephone, constructed like Reis's, talk, without regard to the principle, the mode or the description given by Reis. It may be conceded that any one skilled in the art can, in the light of present knowledge, accomplish this; but it proves nothing except that those who know how can so adjust and arrange the Reis transmitter that it ceases to be a make-and-break device which will not transmit quality, and becomes a microphone, which will. The only witnesses produced by McDonough who claim to have been able to transmit speech by means of a Reis instrument, when called upon to explain the conditions, practically concede this.

If, therefore, Reis never invented a telephone or transmitter capable of transmitting articulate speech, if the art of transmitting speech by a transmitter was unknown, and McDonough makes no claim to have invented more than a receiver to co-operate with a Reis transmitter, what reason is there to open up the interference to enable McDonough to introduce evidence of operativeness, that the Reis transmitter does transmit quality? He could without doubt produce witnesses to testify that they to-day could make the Reis transmitter transmit quality; but is it not clear that that is not the question at all? The question is: Did Reis possess, and does McDonough's application show, the knowledge of the principle of construction and mode of operation which explains the transmission of speech (if they ever did transmit it), and which, without later knowledge and discoveries of others, could have communicated that knowledge to the world? This question has already been sufficiently answered in the negative.

What has been said in Gray's case in regard to the claim that a receiver of multiple tones is also a receiver of quality, because of its potential qualities of responding to every variation in the magnetic and electrical force, is equally pertinent in its application to McDonough's receiver. This appears to have been the view of the Examiner of Interferences; at least this result would seem to follow the adoption of his views; but the Examiners-in-Chief and the Commissioner disposed of the matter as stated. Say the Examiners-in-Chief:

"Gray formerly insisted, and Edison and McDonough still insist, that not only the art is of their invention, but the apparatus also, and it is only by including an articulating transmitter in this issue that the question of priority as to the receiver can properly be determined.

"If the construction of the issue given by the Examiner of Interferences is to prevail, and priority be awarded to a party who had no articulating transmitter, it would result that an experimenter who had tried to transmit speech and failed, or one who had never tried, should so dominate the art that an inventor who had worked out the idea, patented his process of carrying it out, introduced it to the public and put it into extensive use, could not practice the art which he had created without being tributary to his unsuccessful rival."

This construction of the issue was insisted upon by McDonough throughout the interference, not only when Bell moved to re form the issue before Commissioner Paine, but ever since, up to the present petitions. Not only is it the correct construction, but McDonough cannot, at this late hour, ask to have a different one given to it as a ground for rehearing.

As frequently stated by me, in view of the state of the art, when McDonough's application was filed no one could secure a broad claim for a receiver *per se*. A receiver of tone or pitch would not have been patentable in the absence of the invention of a transmitter which would transmit tone; and while it is true that a receiver of quality will necessarily respond to tone, yet the reverse is not necessarily true. As to such a receiver, it is dependent upon a transmitter through the umbilicus of patentable combination and necessary union, and cannot be said to have been discovered or invented until a transmitter of articulate speech had been invented or discovered.

It is insisted, however, by counsel for McDonough that speech was occasionally transmitted by the transmitter constructed after Reis; and whether it occured accidentally and was attributed to the wrong cause or mode of operation, it was articulate speech, reproduced and delivered by the magneto diaphragm-receiver; and that while McDonough might have been ignorant of the mode of operation of the transmitter he was not of that of the receiver, whose functions had long been known. This, however, is, in effect, a complete reversal of all that McDonough has insisted upon heretofore, and eliminates the articulating telephone from the issue and leaves remaining only a receiver. Why McDonough insisted upon the former construction of the issue, unless he thought it the correct one, does not appear, except he may have feared that as to a mere receiver Edison, Gray or Voelker might antedate him. Evidently he cannot be permitted to secure an award upon a limited issue which puts all his adversaries out of the case, and then insist upon another and broader construction for himself. Not only this, but the relation between the receiver and transmitter is such that the invention is not complete as to the receiver until it is as to the transmitter also. They are one in the conception and completion of invention, and cannot be divided or separated. It could not be known that such a receiver wonld reproduce quality until a transmitter could be found to transmit it. If quality were transmitted accidentally and only occasionally, it could not be certainly and absolutely known but that the failure to transmit regularly and when desired was due to a defect in the receiver. In other words, it required a result which could be controlled and relied upon, which could be repeated at will, and that the construction and mode of operation should be known and understood as required by the patent law. This involved the transmitter as well as the receiver, and until a transmitter had been made which would successfully transmit speech, whose construction and mode of operation were understood, there could be no invention of a receiver, within the meaning of that law.

It is urged most strenuously, however, that this question of operativeness is one belonging to McDonough's case *ex-parte;* that in the interference the Office is bound by the action of the Primary Examiner who declared the interference, and that the only mode of considering or reviewing that question is to remand the case to the examiner and give McDonough an opportunity to be heard and present proofs before him. Further, it is insisted that when the right to a patent is denied for want of operative-

ness or utility, it must be by rejection, by the Primary Examiner giving the applicant his right of appeal; but this view cannot be maintained. The Commissioner, as the ultimate head of the Patent Office, has the power to withhold a patent which in his judgment ought not to issue; but the present question does not depend upon the power. There are two modes of rejecting an application: one upon references, want of utility, etc., as an *ex-parte* case; the other through the procedure of interference. The former may be appealed from the Commissioner to the Supreme Court of the District of Columbia; in the latter, the decision can be reviewed only by a bill in equity.

The statute requires an interference to be instituted whenever, in the opinion of the commissioner, there is pending an application which interferes with another or with an unexpired patent. This interference was declared at a time when the nature of the telephone was not so well known and understood as now. I am not prepared to say but that a motion to dissolve should have been sustained if urged upon the ground that McDonough and some others of the parties did not disclose an operative invention. A motion to reform was made, which, had it been sustained, might have remanded McDonough's case to the Primary Examiner; but he opposed the motion and insisted upon the interference and elected that mode of trial. The trial has progressed through several years, and a final decision has been reached. There is not the slightest doubt that in determining the question of priority in such interference proceeding it is right and proper for the Commissioner to determine and pass upon the entire merits of each invention involved, including utility, operativeness, etc. The very question involved is, When did the respective parties first make the inventions set forth in the issues? If the evidence shows that one of the parties never made any invention, as defined in the statute, and consequently is not entitled to an award of priority, while another party did and is so entitled, the Commissioner is unquestionably authorized to so decide and award priority of invention accordingly. He possesses the power in such case to dissolve the interference if he thinks best to do so, but he is not required to do it. In cases of doubt, when he is not certain as to the want of operativeness, he may very properly suspend or dissolve the interference, remand and make the case *ex-parte*, giving the right of appeal, so that the question could come back to him illuminated by the action of the Primary Examiner and the Examiners-in-Chief. If the doubt as to operativeness should be resolved in favor of the applicant, the interference would be reinstated and decision made accordingly; but where there is no doubt, when the question is one settled in the Office, settled in a number of circuit courts and by the Supreme Court of the United States, such a course cannot be seriously considered.

This is all that is asked by McDonough. His petition is, in effect, a motion to dissolve and be permitted to establish to the satisfaction of the Patent Office the operativeness of the invention. He claims that, in consequence of the collusion and the manner in which the interference has been conducted, he has been deprived of an opportunity to do this. It is expressly stated by his counsel that "it is not supposed to be possible in another hearing that any addition to the testimony could be made." He was offered, on the hearing before me, opportunity to present any experiments or tests proving his case, but none were submitted. The question of collusion has been disposed of. The record shows that Bell in taking his testimony directly attacked the operativeness of McDonough's invention, and he had knowledge of the fact personally as well as by counsel. He had ample time allowed him to rebut this evidence and establish all he could; but he took no such evidence. Neither did he ask the Office to enlarge the time, nor did he make any motion in that direction. Having had all these opportunities and neglected them he cannot now complain if it is denied any further time; but it would not avail him if he were given. The alleged fact is incapable of being established.

It thus appears that McDonough's application has received the consideration provided for it under the statute. The interference has been pending since 1878. Final decision was rendered by the Commissioner on March 3, 1885, in which it was held that McDonough had never invented a speaking telephone, and consequently was not entitled to an award of priority, as against Bell, who had. The present petitions ask me to vacate this decision, remand the case, etc. It is to be disposed of upon the principles applicable to new trials.

I am not convinced that there has been any error or mistake in the former decision: but, on the contrary, I am satisfied that another trial would necessarily result in the same conclusion. McDonough's petitions are therefore denied.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

THE CONVENTION AT CHICAGO, FEBRUARY 19-21, 1889.

The ninth convention (fifth annual meeting) of the National Electric Light Association was held in Chicago, February 19th, 20th and 21st. The sessions were held in the Exposition building.

TUESDAY'S PROCEEDINGS.

In calling the convention to order, the president, Mr. S. A. Duncan announced that, in the absence of Mayor Roche, the convention would be welcomed to Chicago by city electrician John P. Barrett.

Mr. Barrett then addressed the convention as follows :—

Mr. President and Gentlemen of the Convention:

His honor, Mayor Roche, requested me yesterday to say to you that as a subject of vital importance to the city of Chicago was being discussed this morning in Springfield, it was absolutely necessary that he be there, but he hoped to pay his respects to this organization to-morrow, or sometime during the session. He also requested me to extend to you the courtesies of the city, the freedom of the town, but on looking over the great number of my old friends whom I see here this morning, I am satisfied that the city is not large enough to contain all of you, and, therefore, I include, in your welcome to the city, the parks and the boulevards.

The president briefly expressed the thanks of the association for the welcome of the city authorities, and then made his opening address.

THE PRESIDENT'S ADDRESS.

Gentlemen of the National Electric Light Association:

But few of the gentlemen of this country who are commercially connected with the manufacture and distribution of electric light and power, and the apparatus used therefor, are aware that five years ago this month, a handful of men met in this city and organized a movement which has grown into the large and powerful organization of which we are members, and which is in session at the present time.

The industry of electric lighting at that time was carried on with all the enthusiasm which comes with a new undertaking, and with the mistakes which are sure to arise in the commercial introduction of any great industrial agency. The gentlemen engaged therein, strangers to one another, working independently, with no attempt at harmony, with but little knowledge of one another's methods of business, with no established custom or precedent to guide them, came together for the purpose of deriving those benefits which invariably result from the deliberate discussion of those mooted questions which are common to the experience of all electric light men.

To even enumerate the topics which have been discussed at the various conventions of this association, the reports which have been rendered by special committees, the papers which have been presented by recognized experts in the various departments of electrical engineering, and the discussions which have taken place between those well qualified to speak, would consume more time than your president feels at liberty to take for such a purpose from this association. Fortunately, the association is in possession of a complete set of published proceedings from the first convention down to the present time, and these volumes, many hundreds in number, now reposing in the electrical libraries of this country and abroad, testify to the steady and yet rapid growth of the industry and the increased information on the part of the whole electrical fraternity on the general subject of electric light and power. It may be remembered that in the early days of this association the chief question before the electrical fraternity was the then all-important question of arc lighting. The incandescent light had scarcely come into commercial use. No sooner had the questions involved in arc lighting been solved by the natural pressure of public demand than the complicated questions involved in the distribution of incandescent lighting absorbed the attention of the fraternity, and occupied the meetings of this association. Following closely upon the problems involved in incandescent lighting came the question of electrical distribution of power, first for stationary motor purposes and afterward for the purpose of electrical locomotion. This question is to day, perhaps, the most important one before the electrical fraternity. To say that electrical power is not to-day a success would be to reflect upon the

scores of electrical railways now in successful operation in this country, and upon the thousands of electrical motors that are every day commercially serving the wants of man.

Electric light and railway statistics.	February, 1888.	August, 1888.	February, 1889.	February, 1888, to February, 1889.
Central station and isolated plants	4,000	5,351	5,747	....
New central stations and isolated plants	....	1,351	396	1,747
Per cent. increase of central stations and isolated plants	....	33.8	7.4	43.7
Arc lamps	175,000	192,500	219,924	....
Increase of arc lamps	....	17,500	27,424	44,924
Per cent. increase of arc lamps	....	10.	14.2	25.6
Incandescence lamps	1,750,000	2,142,440	2,504,490	....
Increase of incandes'nce lamps	....	392,440	362,050	754,490
Per cent. increase of incandescence lamps	....	22.4	16.9	43.1
Increase in capitalization of electric light companies	....	$42,210,100	$27,187,634	$69,397,734
Electric street railways in operation	....	Total 34	Inc. 19	Total 53
Electric street railways being built	....	83	Dec. 39	44
Electric street railways incorporated but not yet contracted for	....	39	Inc. 8	42
Electric cars in operation	....	223	" 155	378
Electric cars under contract; roads not yet finished	....	244	" 185	429
Miles of single track in operation	....	138	" 157.5	295.5
Miles of single track under contract, not yet in operation	....	189.5	" 84.25	273.75

We may here profitably consider some figures indicating the growth of the electric lighting and power industry, the increase in the number of central stations, arc and incandescent lamps, electric motors and electric railways now in operation. At the meeting of this association one year ago, it was estimated that there were not less than 4,000 central station and isolated plants in operation in the United States. From the accompanying statistical table, it may be seen that the number of central station and isolated plants at the August meeting of 1888, was 5,351, and at the present time is 5,747. This shows an increase during the first six months of the year, of 1,351 central station and isolated plants, and an increase during the latter half of the year of 396, making a total increase during the year of 1,747 plants. Figuring in percentages, the increase during the first half of the year was 33.8 per cent. in the total number of central station and isolated plants, and during the latter half of the year it was 7.4 per cent., making a total increase for the year of 43.7 per cent. It was estimated a year ago, that there were 175,000 arc lamps in daily use in the United States. Six months ago I found upon investigation that there were 192,500. At the present time I find that there are 219,924, making an increase during the first half of the year of 17,500 arc lamps, and during the latter half of the year, an increase of 27,424, making a total increase of arc lamps in use during the whole of the year of 44,924. Figured in percentages, the increase the first half of the year shows 10 per cent., the second half 14.2 per cent., making a total gain of arc lamps for the year of 25.6 per cent. A year ago it was estimated that there were 1,750,000 incandescent lamps in use in the United States. Six months ago I found that there were 2,142,440. At the present time there are no less than 2,504,490, making a gain during the first half of the year of 392,440, and during the latter half of the year of 362,050, or a total gain for the year of 754,490 incandescent lamps. Figured in per cent., it shows a gain during the first half of the present year of 22.4 per cent.; during the latter half 16.9, a gain during the whole year of 43.1 per cent.

It is also interesting to notice what the increase in capitalization has been in electric light companies of the United States during the year. During the first half of the year the increase was $42,210,100 ; during the latter half it was $27,187,634, making a total gain during the year of $69,397,734.

It is also interesting to note some comparative figures upon the electric railway industry. Six months ago there were 34 electric railroads in operation in the United States. During the last six months there has been an increase of 19, making at the present time a total of 53. Six months ago there were 83 roads in process of construction. There are 39 less at the present time, making the number of roads now under construction, not finished, 44. Six months ago there were 39 electric roads incorporated in the United States upon which construction had not yet begun ; at the present time there are 42. Six months ago there were 223 electric cars in operation. Since that time 155 have been put into commission, making, at the present time, 378 cars in operation. Six months ago there were 244 cars under contract but not in operation. This number has increased by 185 during the last six months, making a total of 429 electric cars at present under contract but not running. Six months ago there were 138 miles of single track in operation ; during the past six months there has been an increase of 157½ miles, making a total at the present time of 295½ miles of single track in operation. Six months ago there were 189½ miles of single track under contract but not in operation. At the present time there are 273¾ miles of single track under contract but not in operation. It would be profitless for me to draw elaborate deductions from these figures ; they tell for themselves the story of prosperity and rapid growth throughout every department of the electric light and power industry.

Acting under resolutions passed at the last convention, the president of this association established a headquarters in the City of New York, in charge of the secretary and treasurer, on the first day of October, 1888, which action was confirmed by the executive committee on November 19. From this office has been carried on a voluminous and elaborate correspondence with the whole lighting and power fraternity of this country, not only upon the subject of the work of the various committees of the association, but also in regard to this most important feature, the exhibition of electric light and power apparatus. For the first time in the history of the National Electric Light Association, this has received the prominence which it merits. The exhibit which appears in the other rooms of this building testifies not only to the interest which is shown by the electric lighting and power men of this country in the apparatus which is now before the market, but it also shows the fact that the manufacturers and dealers in apparatus and supplies are willing to put themselves to expense and trouble to bring their wares to our notice in a suitable and proper way, when we are gathered at our meetings. Although this movement originated prior to the last convention and the correspondence pertaining thereto has been carried on by the New York office, I wish to say that much of its success is due to the admirable and methodical management of the chairman of the executive committee, Mr. B. F. Sunny, of Chicago. We are gathered at the present time, gentlemen, not only for the purpose of seeing an exhibit of the latest forms of electrical apparatus and supplies, but primarily for the purpose of listening to papers and discussions upon all important electrical questions. I will not burden you with a detailed account of these reports and papers and discussions which will come before this body. Some of the subjects deserve special mention. Petroleum for fuel first received attention from this body at its last meeting. At this present meeting several papers will be presented upon this all-important subject. The question of the materials of underground conduits in relation to the insulating materials of cables will also be treated. The mooted question of static charge on underground cables and the attendant puncturing thereof will also be the theme of an elaborate paper. Electric light stations as fire risks will be comprehensively treated by a recognized expert in fire underwriting who has given especial time and attention to this particular branch of the subject. The question of municipal lighting, which is pressing upon the electrical fraternity to-day, will be the subject of one or two papers, and no doubt of a profitable discussion. The numerous committees of this association have reports to make upon subjects which will be of much interest to all. The committee on underground conduits and conductors has carried on an enormous correspondence with the entire electric lighting fraternity of this country, and it seems eminently proper that the information they have gathered should be presented in this city of Chicago where the subject of the undergrounding of electric lighting wires has been more practically carried out than perhaps in any other city in the world. This question, which is at present one in which diverse opinions are held by men of equal professional standing, is one which this association cannot afford at the present time to ignore or overlook.

"This association is at the present time in a flourishing financial condition. By this we do not mean that we are rolling in wealth, but that we are comfortably able to pay our bills. Since our last meeting the entire membership roll has gone through a revision, the memberships at the present time being vested in individual names instead of corporations. This has, of course, involved an enormous amount of correspondence and a vast outlay of time and trouble. It has, however, been successfully accomplished, and at the present time the roll of live, new members, testifies to the wisdom of this action. Although the association offers its membership to every gentleman actively interested in the electrical distribution of light and power, it is undisputed that it should contain more than three times its present number. It is believed that the association is now on that "tide in the affairs of men which leads on to fortune." With the proper exercise of care in the management of the association, it is felt that the enormous growth of the industry and the consequent influx of hundreds of men into its ranks will lead to a much greater increase in the roll than there has ever been before. The gain of new members since Jan. 3 evinces the fact that an interest is being taken in the association by the community at large."

At the call of the roll about eighty members responded.

On motion of Mr. J. F. Morrison, it was declared by vote that,

during the session of this convention, twenty-five members be considered a quorum for the transaction of business.

On motion of Dr. O. A. Moses, of New York, it was voted that a committee of five on revision of the Constitution of the Association be appointed, and be directed to report at the next regular meeting.

The chair announced that he would name the committee later on.

A motion by Mr. Geo. M. Phelps, of New York, that the convention proceed to the selection of a committee to nominate officers for the ensuing year, and to select a place and time for the semi-annual meeting, was laid on the table.

Mr. Allan V. Garratt then read his report, as secretary.

SECRETARY'S REPORT.

Total number of members on previous record...	189
Number of old members who have resigned or do not reply .	76
Leaving of the old membership now in good standing.......	113
New members added since Jan. 3	62
Making membership paid up on Feb. 18, 1888...............	175
The treasurer also has letters requesting their names to be placed on roster, but not accompanied with checks...	23
According to the constitutional provision therefor, the names of the twenty-three gentlemen cannot be added to the books, though they would swell the roll to...............	198

It was moved that the secretary's report be accepted and referred to the executive committee.

Mr. Garratt read his report as treasurer, as follows:

The last treasurer's report rendered to the association shows a balance of $1,935.23. This has not been received by the present treasurer, and the present account will begin with no balance. The receipts between Nov. 20, 1888, and Feb. 18, 1889, are $3,712; expenditures, $100.08; cash on hand, $3,611.92.

There are bills outstanding against the association incurred by the treasurer under advice of the chairman of the executive committee; when paid from the funds now in the hands of the treasurer there will be a balance on hand of $2,556.18.

The report was referred to the executive committee.

The President—The executive committee is not prepared to report, and if there is no objection further time will be granted. The next order is reports of special committees. The first is the report of the committee on patent legislation by Mr. Steuart of Baltimore.

REPORT OF COMMITTEE ON PATENT LEGISLATION.

Arthur Steuart:—I have only to make a report to you of what has been done during the past six months, and to state that we have accomplished something in the direction in which we have been striving: we have not done all that we hoped to do, but we feel that we are in a position to carry on this work with success in the near future. At the last meeting of this association held in New York, I had the honor to report to you that the bill which we had introduced in Congress was pending before the judiciary committee and that I had reason to expect that the committee would make a favorable report on our bill and recommend its passage by Congress. Since that time they have made a report, and I will read the report which they have made.

Mr. Steuart then read the reportof the House Judiciary Committee on the Court of Patent Appeals Bill (see ELECTRICAL ENGINEER, p. 508, vol. vii.)

After reading the report, Mr. Steuart made the following remarks:—

At the last meeting of the association, I read in your hearing letters of recommendation which I had received from the members of the Supreme Court of the United States, recommending the passage of this bill and the establishment of this court. I have in my hand a letter from the secretary of the president of the United States, in which he says that he has given the matter very careful consideration and is deeply interested in the establishment of a court of patent appeals. I also have here a quotation from the President's message of December 3, 1888, in which he says:—

"The crowded condition of the calendar of the Supreme Court of the United States, and the delay to suitors and denial of justice resulting therefrom, has been strongly urged upon the attention of the Congress with a plan for the relief of the situation, approved by those well able to judge of its merits."

I have, finally, a letter in my hand from the chairman of the judiciary committee who made this report and who has our bill in charge, and who is doing everything possible to have it pass. Together with the chairman, I have moved all the powers that were at my command during the past six months to secure a time for the consideration of our bill. There is no opposition to it whatever. There is no reason why it should not be passed, except that the calendar of the House is so overcrowded with other bills and the time of the House is so occupied with political matters, that nothing of a private nature can be expected to be acted upon. I have here a letter from Judge Culbertson, in which he says: "The committee on rules did not consider favorably the proposition to give the committee on the judiciary time for the consideration of our bill for a court of patent appeals. The committee on rules has entire control of what bills shall be considered, and unless they give the time for consideration no bill can get place before the House.

It is simply buried under an enormous mass of other matter. But the bill is in shape for introduction into the next Congress, and everything is ready for us to begin work again in November, with every reason to expect that we will succeed. We began to consider this matter at the early part of the present fiftieth Congress. It took six months to get the bill into such form as we could all agree upon. It was filed in April. It took me until the first of September or latter part of August to get this report from the judiciary committee favoring the bill and recommending its passage. Since then you have heard its fate; it has lain with thousands of other bills.

The report was ordered filed.

The committee on transportation reported its success in obtaining reduced fares from all points east of Chicago, Peoria, St. Louis and the Mississippi River.

The President—The next committee to report will be the committee on Insulation of Wires and Installation of Plants.

Mr. Morrison—The duties of that committee are of such a character that no one engaged in the electric lighting business would care to attempt to fulfill them. It practically involves a decision as to whose wire carries the best insulation. We have carried upon our committee lists for several years this committee on insulation, and we have never yet had a report from them. Professor Barker, Mr. Hering, Professor Houston and a large number of scientific gentlemen, were assigned to this duty at one time, and the prospect was that we would get from them a report; but when the time came, owing to the inability of the association to provide the scientific instruments for the tests which were necessary to determine certain qualities of insulation and for other reasons—notably, the lack of an appropriation to be placed at the disposal of these gentlemen, and without which they could not operate to any advantage—they were unable to make a report, except a partial one, which I take it is now among the archives of the association. With this condition of things before us, and believing that we are only lumbering up your committee list by retaining this and perhaps some other committees upon it, I move you, sir, that that committee be discharged from further consideration of the question.

Mr. Morrison's motion was carried, and the committee was discharged from further duties.

The Chairman of the committee on Electrical Education reported that no action had been taken, that the proposed establishment of electrical courses at Columbia College and elsewhere, rendered action by the committee superfluous, and asked for its discharge.

The report was accepted and the committee discharged.

The President—Before we adjourn, the chair desires to state that he has appointed as a committee on Revision of the Constitution, Dr. Moses, of New York, A. J. DeCamp, of Philadelphia, M. J. Perry, of Providence, Henry D. Stanley, of Bridgeport, and W. L. Candee, of New York.

The convention then adjourned till Wednesday morning at 10:30 o'clock.

WEDNESDAY'S PROCEEDINGS.

Upon the calling to order of the convention at 11 o'clock, Dr. Moses, on behalf of the Central Electric company of Chicago, agents of the Okonite company of New York, presented President Duncan with a gavel, hastily but cleverly and handsomely made of a piece of cable.

The President gracefully replied an acceptance.

Mr. Eugene T. Lynch, Jr., read the report of the committee on Underground Conduits and Wires, as follows:—

REPORT OF COMMITTEE ON UNDERGROUND CONDUITS AND CONDUCTORS.

Gentlemen of the Electric Light Convention:

At the eighth meeting of the National Electric Light Association, held in New York on August 29th, 30th and 31st, the following resolution was offered and adopted:

Resolved, "That a committee of five be appointed by the chair to examine into and report upon the system of underground conduits, with underground conductors and conduits now in operation, and the number of wires actually in use in these conduits, and to report at the next meeting of this association."

The president appointed Messrs. Lynch, Barney, Kerr, Davis and Crocker as members of that committee. And as chairman of that committee, I beg leave to submit to the convention the following report:—

As the resolution called for a compilation of all data connected with the actual placing of electrical wires underground, your committee deemed it advisable to send out a circular, calling upon and asking all the local electric light companies for the results of any practical tests that they had made.

To carry out this idea, they caused to be printed the following circular:—

"*From the Committee on Underground Conduits and Conductors:*

"*Gentlemen:* A committee was appointed at the semi-annual convention of the National Electric Light Association, held in New York August 29th, 30th and 31st, to investigate and collect all data relating to underground wires and conductors, both in this country and Europe. It is the intention of this committee to present this report at the Chicago convention of this association, which will be held on February 19, 20 and 21, 1889.

"So many erroneous statements have been made, from time to time, regarding experiments or tests with underground wiring, that the committee (in order that it may hear both sides of the question) feels that it is necessary to obtain all of the most important details and facts regarding this subject.

"Will you, therefore, kindly answer, as far as may be in your power, the following questions, and return the same to the headquarters of the association as soon as possible? Your answers to these questions will be looked upon as confidential, and will not be referred to by name or locality in the report of the committee. It is desirable that you send in your answers at once, as the compilation of statistics takes time."

Yours very truly,

EUGENE T. LYNCH,
Chairman.

ALLAN V. GARRATT,
Secretary.

1. Have you ever placed underground, any electric light conductors, carrying currents at a potential of 1,000 volts or over? 2. If so, state the number of experiments, giving the date of each. 3. What was the length of each individual conductor laid underground? 4. What was the voltage on each conductor? 5. What was the current, in amperes, carried by each conductor? 6. What make and style of dynamo supplied the current on each of these conductors? 7. Were these conductors single or grouped in cables? 8. How many conductors to the cable? 9. What was the size of the conductors used? (In answering this question give the number and gauge.) 0. What was the thickness of the insulation? 11. Who was the maker of the cable? 12. Were the cables laid in any form of conduit? 13. If so, what kind of conduit was used? 14. Describe the manner in which the cables were laid in the conduit—whether drawn in, built in, or otherwise. 15. If the cables were laid directly in the ground, describe the method of laying them. 16. Was there more than one duct in the conduit? 17. If there were other ducts, what was in them? 18. Did you have exclusive control of the conduit? 19. What was the total duration of your experiments? 20. Did the cables work satisfactorily during the entire time of your experiments? 21. If not, how long did they work satisfactorily? 22. If the cables failed to work satisfactorily, to which of the following causes do you attribute the difficulty? Please answer as fully as possible: *a*. Defective insulation; *b*. Defects in joints; *c*. Defects in making connections from cables to lamps.

These were sent to all of the local electric light companies, and in response to them we have received 130 answers. In presenting and compiling the answers to the various questions that were sent out, we have deemed it advisable to divide them into two classes, as follows: Those who have had actual experience in placing and running underground electric wires and those who have not had actual experience, but whose opinions we have asked. Of the former class there are but seven. We will here give the details of the placing of the wires underground, the duration of tests, style of conduit used, and the general results, that were received in each of these seven answers.

As it was stated in the circular sent out that all the communications would be regarded as strictly confidential, we have deemed it advisable that the names of the companies or individuals should not be mentioned in this report; consequently we will not refer to them by name.

First. The writer has used the underground conductors for three years. Has used wire of three of the most prominent manufacturers. Has discarded two and is now using the third. The cables were carried in a cement pipe, and man-holes were placed at every 250 feet. Cables had been drawn into the conduits, and as a method of facilitating their drawing in, pulverized soapstone had been used for the purpose of avoiding abrasion.

Only one wire placed in each pipe. He states that the wires have not worked satisfactorily, and that he has been compelled to shut down many times, that they are now running fairly well, but he is obliged to keep them under constant supervision and repair. He accounts for most of the trouble that he has experienced by defective insulation, defective mechanical construction, and by deterioration in the insulation in the wires, having had no serious trouble with the style of conduits that he has used. In answer to the twenty-seventh question regarding the practicability of placing his conductors underground, he states: "We are operating some eight miles of underground wire; we wish there were less, and certainly are not anxious for more." In answer to the twenty-eighth question, regarding the difficulties and objections to underground wiring, and whether he considered them commercial, electrical or mechanical, he states: Electrical.—There is no cable that will last with a current from a 50-light dynamo. Commercial—Owing to the large cost of construction and expense of maintenance, and great possibility of breaks, there is consequently poor service and dissatisfaction. He has exclusive control of his conduit.

Second. The writer has made many experiments in which he has used lengths of cable varying from 200 feet to two miles in length, manufactured by most of the prominent wiring companies. Cables have been laid in and drawn in, in his own conduits, conduits constructed of both wood and iron. The tests have usually been of short duration, and have been suspended in each case after a failure of the cable to work satisfactorily. The cause of the failure has been, mainly defective insulation. Defective mechanical construction, defects in laying, defective conduits, injury to cables in laying, or defective joints, have caused very little trouble, the main cause of trouble being in defective insulation, and deterioration, owing to the presence of gas, water and steam.

His opinions, based upon the results brought out by the many tests that he has made, is that "he does not consider it practical at the present time to place conductors underground, the absence of insulation that would stand being the principal reason. If ever the question is settled, the cost would, in his estimation, make it commercially impracticable. In only one instance he had the exclusive control of the conduit.

Third. The company represented by the writer had four circuits underground for about one year. One style of cable only, manufactured by a prominent manufacturer, was alone used. The wire was drawn into a composition conduit, which had manholes at the corners.

Quite an amount of trouble was caused in the start of, by difficulty caused by abrasion to cable in drawing the wire into the conduit. The experiments were continued for one year. They caused a great deal of trouble within the lighting contracts, and at the end of that time were abandoned. He considers his chief troubles to be defective conduits, water in the conduits, and deterioration of the cable, also trouble in defective insulation, defects in the joints, and trouble in making connections through iron pipes from the conduit to the surface.

His opinion, based upon the results of the tests that he has made, is that he does not consider it practicable to place his wires underground, and states: "I don't know of any system that has yet proved satisfactory;" and further states: "I know of no system to-day which, even at any expense, has proved satisfactory, except a system of subways built large enough for men to walk through their entire length."

In answer to the difficulties of placing wires underground, he states that he considers the difficulties to be commercial, electrical and mechanical perfection, and still not be so expensive (in the end) as to make the commercial objection insurmountable.

We are all in the business simply to make money, and the commercial objection must be met just as much as any other. He did not have exclusive control of the conduit.

The ordinance passed by the common council in his city in 1886 stated "that their committee had examined the subject and found the putting of all electrical wires underground feasible, and ordered all wires within a few months, and those outside of this district, underground within one year." He has been brought before the court a number of times on complaint of the city attorney, but nothing yet has been done in the matter.

Fourth. The writer has made two experiments during the last summer, one of which was a failure, and the other a partial success, though the duration of the second test and the position it occupied in the circuit was such as to give little importance to the result. The wires were pulled into a wooden conduit, there being two ducts in each conduit. Cables did not work satisfactorily. He states that the failure is due entirely to defective insulation.

In answer to the question if he considers it practicable to place his conductors underground, he replied, "We do not, with any system known at present."

In answer to the last question, concerning the difficulties and objections to placing wires underground, he states: "The difficulty is particularly commercial, though I have seen no system which I think will properly insulate the conductors."

Fifth. The writer has placed two circuits underground about the first of the present year. The cables used are those manufactured by six of the most prominent companies. They have been drawn into an asphalt conduit, 12 ducts in each conduit. The duration of his experiment has only been about a month and a half, and he states that it is too early to tell what will be considered the result of the experiment.

In answer to the question if it would be considered practicable to place the wires underground, he states, "Have seen nothing yet that will answer."

In answer to the question regarding his opinion regarding difficulties and objections to going underground, he replies,

"Chiefly commercial, partly electrical, and partly mechanical." He has exclusive control over his own style of conduit.

The writer has had wires in the conduits for about five years. The mains were carried through the streets in a composite system of conduits, the connections are made from the system to the cellars through iron pipes, and the wires are conveyed then through cellars, connection being made from the cellars to the houses. The cellars run completely around the block, and permit of free access to them for the purpose of repairing or making connections to wires.

He has used three different kinds of wires in the conduits, the cables now in use having been in position for about 13 months; although he has had trouble with them, he claims that satisfactory service can be maintained in his particular locality, as he considers the question of the distribution of power and light an exceedingly simple one in his city, which is probably the only city which is so fortunately situated.

He has in all about 32 circuits. He states that he is on the right track regarding the placing of wires underground, and that the system such as he operates will run satisfactorily. The cables that he is using are guaranteed for three years. The trouble that he had with his first wires was mainly due, as far as he can ascertain, to the fact that the insulation surrounding the wires was not of sufficient thickness, and the main conduits themselves were not dry, He controls his own conduits exclusively.

The writer has made some practical experiments and tests with cables underwater; these were manufactured by two of the most prominent companies. The cables did not, however, work satisfactorily, lasting, as they did, from three months to one and a half years. He lays the cause of failure to the effect of water upon the cable, and the deterioration in the insulation of the wire. His opinion, based upon the tests he has made, is that he does not consider it practicable to place his conductors underground; considers that the difficulties are electrical, mechanical and commercial; had exclusive control over such conduits as he used.

In summarizing the results of the experiments in these cities, in one case only did the electric light company place its wires underground willingly; in all others they were forced to do so by the local authorities.

In only one instance have the experiments or practical workings proved satisfactory; the only other case that they did not report adversely being where the wires had only been in operation about 40 days. The average voltage that we used on all the circuits tested was 1,893 volts; the current was 10 amperes; the average thickness of insulation over wires was 9.32 of an inch, and the average length of cables tested in each case was about 4,600 feet.

In considering the second class of answers, namely, those who have not yet made any extended practical test, their answers have been directed mainly to the last four questions, the first two of which relate to action by the municipal authorities, and the last two consider the practicability and the difficulties of placing wires underground.

In very few of these cities have the municipal authorities yet taken any steps toward action upon the matter, having been delayed in awaiting the solution of the underground question in other cities.

In answer to the 27th question, asking them if they considered it practical to place their conductors underground, 104 have replied that their opinions, based upon tests that they have seen and such information as they have been able to obtain, both in this country and abroad, is "that it has not been practical to place the wires conveying high tension electric arc light currents underground."

Two have answered that they considered it practical to do so, but state that at the present time they have no wires underground.

In answer to the 28th question, which asks their opinion regarding the greatest difficulties to be met with in considering the placing and operating of underground wires, they all unite in the opinion that the difficulties are mechanical, electrical and commercial.

They consider that the question of obtaining a satisfactory conduit has not been properly solved; and that even if that should be solved in the future, we cannot even at this time obtain a satisfactory insulation for the wires that will not deteriorate within a few years, and become perfectly useless as an insulator when subjected to the action of steam, water and gas. The great difficulty of making connections for buildings and lamps, and the absence of any satisfactory system of subsidiary conduits, is considered by all as a bar to successful operation, as the difficulty of drawing in cables without abrasion to the insulating covering, even with the most careful handling, is very great.

The commercial objection is considered a very great one, as not only is the first cost about eight times heavier than that of an overhead system, but the repairs to the cables due to the deterioration of the insulation and other defects caused by mechanical or electrical deficiencies, would be very much heavier than the expense of operating and maintaining overhead systems, and that the prices at which they are now furnishing the electric light would have to be very materially increased to meet these extra and very heavy expenses. A system of tunnels through all the principal streets is considered to afford the only means for the solution of this problem.

There are many other responses to the circulars, in which the writers state that they have had no experience with underground lines, and have not yet considered the question in the light that we have placed it before them.

The committee also sent a letter asking many of the questions that were sent in the circular, to all of the electric underground wire companies, and in response received quite a number of communications from the cable companies. Most of them said that at the present time they were unable to give any information in regard to underground wiring, as they have had very little experience with wires for that purpose, but that they do not doubt that in the future the state of the art will permit of the wires being placed underground, and that their particular company will be well equipped for doing so.

Other companies reply that the wiring of their system that has been used for underground purposes has been for potentials under 2,000 volts, and that they have met with entire success with potentials of a system with 1,000 volts. And they do not anticipate in the future that they will have any trouble in furnishing wire to meet the requirements of the electric lighting companies, but at the present time they have not yet done so.

They unite in stating that they think that the question of the insulation of high voltage of currents should be solved by the using of good, durable, thick insulation.

Their experience in conduits has been, that they do not want creosoted wood, but would prefer to have their wires buried in the ground or under water, and would recommend at the present time that single conductors should be used.

They seem to be about evenly divided on the question as to whether lead-covered cables should be used for underground purposes.

The report was accepted and placed on file.

Mr. J. P. Barrett—I want to say that we have had underground service here in Chicago, for the last 13 years. We have been using electric lights with underground circuits for the last six years. The municipality purposes to extend its electric light system indefinitely. When I see in this convention gentlemen who are prepared to guarantee to construct and maintain conduits in any form that you require, and right alongside of them, gentlemen prepared to furnish you conductors that will carry anything you want—in face of these facts, I say, I find it stated by this report that it is an impracticability. We think pretty well of it here, and we have got plenty of it in service.

Mr. W. H. Johnstone—I have been in the underground electric light business, for five or six years. I have been operating a plant in Philadelphia during that entire time with perfect and uniform success. We have constructed a plant in New York for the same purpose at a very great expense. The reason why gentlemen say the conduits are not practicable is that they have not seen them. In 1883, we laid two miles of conduits in Chestnut street, Philadelphia. At that time the state of the manufacture of the insulation was in a somewhat primitive condition. To-day the manufacturers have advanced so far that they are willing to offer us wires with a guarantee of three or five years' duration of insulation. Mr. DeCamp, who is sittting in front of me, has had an opportunity of seeing what we did in Philadelphia. His company did not want this thing to succeed, and, therefore, they took advantage of the opportunity to get possession of it. They ran it to suit themselves, and in a very short time announced that arc electric lighting underground was not practical, and that they would have to utilize these conduits for an incandescent circuit.

Now as to conduits, I have spent eight years with them. We started out with the idea of grasping the entire subject. The electrical difficulty we knew we could deal with; the mechanical difficulty was the serious one. The first difficulty was expense Our conduit is more expensive than creosoted wood or asphalt, but when you put it down, you have a comprehensive thing that fulfills every demand, and I challenge any one to ask me a question as to the distribution or handling of an electric light current that I cannot answer and show him how it is done. Now, that iron is the best material electrically, I think, we will all admit. I do not see what this report is based upon.

We are laying in New York city conduits that have cost now quite a million of dollars. There have been laid about four miles, and it has proven satisfactory to those people who were so bitterly opposed to this system. Now we have laid that conduit in Broadway and we are going to have it on 125th street, and I promise you that this coming summer the electric conductors in New York will all go underground, and our good friend, Mr. Lynch, will have to reverse his report.

Mr. J. R. Ecclesine, of New York—I see that most of the communications were from electric light companies whose underground conductors were failures; any success seemed to be overlooked or was not reached by the committee. It struck me also that the report of the committee was made up of objections, and that it was made to support the resolution that had declared in New York that underground conduits were not a success. There

have been, I believe, for some time, underground stations worked successfully, not one of which the report happened to name. I take Professor Barrett's word for it that he has worked underground successfully, and yet the report fails to say anything about his experience. In fact, all the information the report brings is damaging to underground systems. But the resolution that is to be supported by this report, passed last August, was of a sweeping nature. It was the effort of people to say, "we don't want to go underground, and, therefore, we will say boldly we cannot go underground." The electric light companies that have answered the committee are evidently not desirous of going underground; but the people of the country are desirous to have them go underground.

I do not think there is any earnest effort on the part of the committee to find how to go underground, but a very earnest effort to find how not to go underground. At the proper time I propose to move to rescind the resolution of August. I propose to do that not because of the opinions of the people, but because of the facts that exist.

Mr. T. Carpenter Smith, of Philadelphia—I do not stand here to declare that overhead wires are dangerous, or that the wires have to go underground. I believe to-day, after our experience of three years with underground circuits and of six years with overhead circuits, that overhead work properly constructed and cared for, is the safest method of distributing. Considering the amount of power now distributed through electric light wires overhead in the city of New York, or the city of Philadelphia, and comparing it with the accidents that occur every day or every hour with any other form of transmitting power, you find that it is incomparably safer. There are about 200 miles of overhead electric light wires in Philadelphia. There are, I believe, about 100 miles of street car track. Now in these 200 miles of wires we are distributing, say, 3,000 or 4,000 h. p. sixteen hours a day. In Philadelphia last year there was one death from an arc light current. What do we find in the miles of car tracks operated by cable companies? Twelve deaths were caused where people fell off the cars or were knocked down by the cars and were run over. I want to put myself on record as a strong and earnest advocate of overhead circuits where they are possible. They are easily kept in order; if there is anything wrong with them it is quickly seen; but on the other hand I must say I do not consider that this report is at all a fair one to the underground wires. When any company wishes to adopt a new system, using, perhaps, some particular form of electric apparatus, do they go around and ask companies who are not using that system what their opinion of it is? No; they pick out men who are using that system and go to them to see what has been their success with it. They are not content with taking the say-so of people; they try to find out the reasons for its failure. Now I am not aware that I have ever seen that circular sent out by Mr. Lynch's committee. I represent the Keystone Construction Company, Philadelphia, and we are operating an underground station. We are doing so because we could not help it. If we could have gone overhead we would have done so.

We have had a great deal of trouble with underground wires, but have managed to keep our lights going. It has cost us less to do that than any similar amount of overhead wire that I know of. When we went into this thing we went into it in an experimental way. There was nobody in this country who could tell us anything about it. Fortunately for myself, when I first went into the electric business, some seventeen years ago, I served my time in a factory where we made submarine cable. I had an opportunity of seeing a great many accidents that happened to ocean cables. We went out in boats and hauled up the cables and found that the accidents were more mechanical than electrical. When we went into this alternate current business I was met with a storm of assertion that we never could run alternate currents—the induction would be too great. We have had not one particle of trouble from induction or anything but mechanical defects or defective insulation. We have found that lead-covered cable does not get proper handling when it is put in. We instruct our men as well as we know how; we threaten them with discharge if they do not do exactly as we tell them; and then they will go to dinner on a damp day and leave the ends of the cable sticking out to absorb moisture. When the cable was watched carefully we have had no trouble. With cables we do not watch personally in every case they have broken down, and in nearly every case it is because it has taken some damage and the moisture worked back into the cable and found the weak spot in the insulation. Now I think in making up the report or making inquiry as to electric light service underground, that the money which was spent in sending out a thousand circulars to companies who were not using underground wire would have been much better applied in making careful inquiries of the companies who were. I do not consider that experiments made with a quarter mile or half mile or ten miles of cable six years ago have very much bearing on this question; for it is only within the last two or three years that a really intelligent attempt has been made to put in underground service. I am free to say that I consider the question of distribution of high tension arc light currents the gravest and most serious case we have to consider. The distribution of low tension incandescent current we may say has been solved. The Edison company is doing enough with that to settle the question. When it comes to the distribution of high tension alternate current for incandescent service, I am free to say I think it is perfectly practicable and can be made a commercial success. I most sincerely trust that this report will not go forth as the voice of this convention. I think the resolution passed last August stating that the underground work so far was not a success was an ill-advised one. I believe the time has come when this association has to face the music. Underground work will have to be put in, and the sooner you do it, or make some honest effort to do it of yourselves without compulsion the sooner there will be a let-up on this tremendous public pressure. In the centre of a crowded city I think no one who has been in Philadelphia, New York or Chicago will deny that the presence of the poles is a nuisance; they are obstructions and to some extent they are a danger. In small country towns and in outside suburbs, I do not consider that the overhead wires are half as much of a nuisance or a danger as underground wires. Now I want to be thoroughly understood as to what I mean by the danger of a lighting circuit. We have been favored with a large number of communications from a distinguished electrical engineer as to the frightful danger of overhead high tension circuits, and he is very anxious to put an apparatus on all such lines which from the moment of a grounding will shut the circuit off. He wants to do that to protect the eight or ten linemen, who are presumably men who understand the danger of their business and will take proper precautions against it. To do that he is willing to risk the lives of the unoffending public who may be jammed in a ferry-slip or in the theatre or on a large public thoroughfare or in a railroad station by having the entire light shut off instantly, leaving them in total darkness. Now that is a form of danger which I think is infinitely greater than the danger that exists from grounding on a high tension line overhead, which is only interfered with by men who know what they are going to do. For that reason I think that the underground service is more liable to interruption; but against that we have to set this fact, that on an alternating transformer system you can run one of these high tensions grounded. Ferranti, in England, proposes to do nothing else. Under the transformer system each house is a unit; a man who puts his own wire in a proper condition cannot affect his neighbor. With the arc light system you cannot do that; there may be a break, and you will have to let your lights go out. For that reason I propose to leave arc lights out of the question. I am putting up overhead wire every day, and I stand ready to put down underground if anybody will pay the price.

Mr. J. E. Lockwood, of Detroit—I am one of the seven who in answering the report of the committee on underground wires, answered that we had tried the underground system. I represent the Thomson-Houston Electric Light Co., of Detroit, where the underground system was tried for a little more than one year, and was discontinued a little over one year ago to-day. Our current was from 1,800 to 2,000 volts. The discussion on the former underground systems for telegraph and telephone wires, does not apply to currents of over 1,000 volts. I think the questions sent out by the committee were good, inasmuch as they focused the subject down to currents exceeding 1,000 volts. I should like to have Mr. Johnstone and Professor Barrett tell us about circuits of over 1,000 volts. I have understood from reports made to this convention by Mr. Sunny and others, that a large amount of the wire used here in Chicago was taken out last fall. I would like to ask if there are any underground wires now in use here in Chicago, with a potential exceeding 1,000 volts, and if there are any exceeding 2,000 that have been in use for any length of time; if so, just the length of wire in use, the potential of the current and the time it has been in use.

Mr. J. P. Barrett—We started in to use them about a year and a half ago. At that time we put in the Western Electric (Patterson) cable. We put in, say, 12 miles of Western Electric cable and six miles of Kerite. We have now 55 miles of underground cable for the lighting service of the city. In the matter of high tension, if you will ask Mr. Sunny he will give you more information. I understand we have some 1,200 arc lights.

Mr. B. E. Sunny, of Chicago—I stated at the Pittsburgh convention, and subsequently at New York, what the condition of affairs was in Chicago with regard to underground cable. At Pittsburgh I stated that we were in a bad condition; that we had to throw out entirely two different styles of cable, and had finally put in cable manufactured by the Western Electric Co.—a lead-covered cable with very thick insulation, an insulation thickness of three-sixteenths of an inch. At New York, six months later, I stated that with six or seven months' experience we had but four cases of interruption. One of these was a mechanical injury, and two were defects in the cable, and one we could not trace. Since the New York convention we have had no trouble that could be traced to imperfections in the cable. We have had some troubles, but they were owing to poor work in making the joints. From a technical standpoint we are getting along nicely in working arc light circuits underground. Professor Barrett is using a current in his work of about 900 volts—perhaps he gets as high as 1,200 volts. We put through our cables from 2,000 to 3,000 volts,

and sometimes higher. Of course, I cannot say how long the cables that we have now—that have been in use for just about a year, and have only given us four cases of trouble—are going to last, or how long they are going to furnish satisfactory service; but just at this time they seem to be in first-class condition; and we are satisfied with them. Scientifically it is all right; the only objection we have is a financial one. I made up some figures a few days ago, as follows: The cost of circuit reconstruction and maintenance of conduit amounted, for three months, to $9,610.95. That was for 1,194 lamps for eight hours a day for 90 days, or 859,680 lamp hours. You see the cost of underground conductors is a trifle more than one cent per lamp hour over and above what it would cost on an aerial conductor. Now, you will say, if we had aerial conductors we would still have the item of circuit reconstruction. That is very true, but I have left out the question of underground conductors so far as the repair on electrical machinery is concerned. We put $200 to $300 worth of expense every month on repairs to the electrical apparatus, made necessary by our underground cable, so that I think it is perfectly right to say that if our wires were on poles, the troubles I have enumerated would be eliminated. We figure, therefore, that from a scientific and practical standpoint underground cables are all right. From a financial standpoint they are costing us a trifle more than one cent per lamp hour more than aerial conductors. That does not include the interest on the additional cost of the investment.

Mr. T. Carpenter Smith—I would ask Mr. Sunny what rent he pays per mile for each circuit. I know of a case where conduit rent was such that in three years the company could have put down and owned its own conduits, and a great deal better conduits.

Mr. Sunny—The conduit rent is a thousand dollars per mile per year per duct. The duct will hold three electric light cables. So that the rent per mile for conductor is $333.33.

Mr. Smith—We can lay down a 16-duct box, which would accommodate 50 wires at a cost complete of a little over $5,000 a mile.

Mr. Sunny—The item of circuit reconstruction which was included in the $9,610 was for going over joints in man-holes, for pulling out some sections of cable and replacing, and for taking out and renewing some wires under sidewalks. It included everything that we did with the plant that we could not charge to construction, everything that we did to the plant that did not add to its earning capacity. Six months ago we were in good shape; all the reconstruction that we ought to have done was done, and from that time on we considered that any charge that we would have to make for reconstruction would be a charge that we could count on having from month to month, as far ahead in the future as we could see. Nothing that can be legitimately charged to construction is put into that account. It is renewing something that we paid for some time ago. The items of the three months' expense account are: Circuit, reconstruction, $3,105.31; maintenance of conduit, $2,206.54; conduit rent, $3,480; rebate for bad service, $789; total, $9,610.95. The conduit needs a great deal of attention. It is one of the first ever put down. It was laid five years ago. Street rollers have crushed it here and there, and we have had to enlarge some of the man-holes. If you put down a conduit as it can be put down to day, it would not cost so much to maintain it. It would not require three or four men going around town every day in the week pumping out the water and drawing out the gas.

Mr. Lockwood—Then I understand that the expense of the maintenance department, including rebates, is approximately $6,200 for three months; that during that period Mr. Sunny's company has been having its greatest success with underground wires. I would like to know if anyone has actually used underground conductors with a potential exceeding 1,000 volts with a record better than this of Mr. Sunny's

Mr. E. A. Sperry, of Chicago—In the last four years we have been operating on State street, an underground system of 1,800 volts, and 18 to 20 amperes; and entering into the construction of that underground system has been every conceivable kind of cable. I do not think, that our expense account, figured in lamp hours, would reach any such figure, including rental of conduits, as has been named here. We are operating now another station in the city with 1,300 volts, with a record of no shut-down whatever, and a record of over a megohm as actual insulating resistance every morning. This is all underground, and is made of improved modern cable and is put in iron pipes under sidewalks. This being more than 1,000 volts I think comes under the question. There has been a great deal of changing, but that was owing to the pioneer work that we had to do. We had to take what we could get. If a cable did not prove satisfactory we had to pull it out and put in something else. Now, the cables that were used for the first three months are undoubtedly all out. As to the next cables that were put in, part of them are out. I have in mind now one cable, put in three years ago, that is now running successfully. That is to my mind a very good instance of what the cable can be made to do if it is properly put in.

Mr. T. Carpenter Smith—Mr. Sunny said that his rental of conduits and repairs to conduits amounted together to about $5,600. Now he is in the unfortunate position of renting a conduit and then having to pay for it in the bargain, which is always the result where you rent conduits from a company in whose power you are, so to speak. That leaves as the cost of Mr. Sunny's conduit for underground service, reconstruction, etc., $4,000, or about $1,300 a month. I would like to ask Mr. Sunny how many miles of wire there are and how many miles of conduit?

Mr. Sunny called upon Mr. C. H. Wilmerding, superintendent of the Chicago Arc Light and Power Co., to reply.

Mr. Wilmerding—We make out the mileage of underground conductors as about 78 miles. There are laid 90 miles of duct and about seven and one-half miles of conduit. Each duct will hold three wires.

Mr. Lynch—I would like to call Mr. Sunny's attention to the following figures: Rental of conduits, $3,400 for one quarter; that would be $13,600 per year. That would be 13½ miles of duct at $1,000 per mile per duct. That would give only 40 miles of wire. Mr. Wilmerding said there were 78 miles of wire underground.

Mr. Sunny—We have 78 miles of circuit, and I should estimate that there are about 40 miles of that circuit in the conduits; the remainder is under the sidewalks and in buildings.

Mr. Lynch—You do not have to pay any rental for the subsidiary ducts which you use—that is, in the cellars and over the buildings.

Mr. Sunny—No, sir.

Mr. Charles Cooper, of Brooklyn—While this underground business is very interesting electrically, and we are very glad to hear the opinions of the electricians on the subject, to the practical operators of electric light plants it would seem that the matter comes down to this—that the experience so far has not been flattering, and that what has been said in favor of the underground system so far, is from men interested in underground conduits or cables, or by our friend, Professor Barrett, of Chicago, who is in the fortunate position of having the municipality of Chicago to pay his bills. Unfortunately our company has to pay its own bills. Mr. Johnstone, who speaks for the Johnstone underground conduit, mentions his conduit in the city of New York, which has not yet been used. The experience of New York city so far leads to the belief that when his conduit is used it will be, as the others have been, a failure. Mayor Hewitt remarked, the commission in the city of New York consisted of four men, who he supposed knew as little about electricity as any four men in the city of New York; and he added that he could frankly say so, because he was one of the commission. Now, I for one would be very glad indeed to have this system of underground conduits prove a success. In Brooklyn we are very anxious to use it. We have a commission in Brooklyn composed of three of our best known professors of electricity, who, I can say, are honest men, appointed by Seth Low, the reform mayor of the city of Brooklyn. One is Professor Plympton of the Polytechnic, another, Dr. Raymond of the Adelphi academy. Professor Plympton traveled all over the world, and went into cities where he was told that all was underground; coming to Chicago where they did not have an overhead wire, and much to his surprise finding that they had more here than they had in Brooklyn; he has traveled to Paris, Berlin, London and every city in the world where he heard they had used the underground system, and much to his surprise found that none of them had been in successful operation, and came back and, like an honest man, made his report to the mayor of Brooklyn to the effect that up to the present time there is no system that is of practical use for arc lighting. Mr. Barrett has started in the electric light field. Mr. Barrett has the city of Chicago at his back. It is a rich city; it will probably not be so rich when it gets through with this conduit business. When it gets through with the system, when it has used it a few years, it will do just what companies have done,—abandon it. You cannot do electric arc lighting and make it a commercial success with underground conduits.

Mr. Johnstone—The only people that are advocating underground operation, we are told, are those that are interested. Why not? The only people who are opposed to it are those who have money invested in overhead wires and do not want to take them down.

Mr. A. J. DeCamp, of Philadelphia—The criticism has been made that the enquiries had been sent without special reference to the companies that were using underground wires, as being the only ones who could express an opinion or give an experience. The number who responded was comparatively small. In my judgment that is an evidence of the good, hard, practical common sense that has got into the heads of the electric lighting men. I think that a man is a grievous fool at this late day who will spend thousands of dollars to try over again anything that I and seven other men have failed in absolutely. There are three things connected with this underground business. First, insulation; second, some method of distributing your business, and after that is accomplished is it a commercial success? Where is the man to tell what cable or wire will cost with perfect insulation? Now, the distribution of it by some properly constructed conduit comes next. So far as my knowledge goes of general construction, the plan for distribution of wires by the conduit in which Mr. Johnstone is so greatly interested is as good as any, and I am prepared to say better than anything I have seen, because I have used it. I do not agree with him as to its construction of iron, but that is a collateral question, it

can be made out of anything. Now, as to the financial success. A statement was made to me yesterday substantially the same as Mr. Sunny made here to-day as the experience of his company. That must be wrong. One cent an hour added to the cost of lights must be wrong. That exceeds anything that I could ever imagine. Mr. Sunny told me it was substantially correct, and he reiterates that statement on the floor of the convention to-day. Now what does that mean? Our average is something over eleven hours; that means it is going to cost us eleven cents a day. Now I have been in the electric lighting business a long time, and I do not think we could get a dollar of capital into that business on any such representations of cost as that, added to other costs which are large, and which you always have with you. Now Mr. Johnstone refers to Philadelphia, and while I regret that I am dragged into that subject, I am compelled to answer. Mr. Johnstone had been manager of that company, spending one day in the week, I will venture to say, in looking after the details of the station, and the other six days advancing the interests of the conduit company—that is my belief. Mr. Johnstone makes a statement about our buying his company out. I will make no reference to that any further than to say that he sold it out at about ten times its intrinsic value. I accepted that station just as it was. I had nothing to do except to look after the interests of my superiors, the directors, and I said: "I have the facilities at hand to see whether this thing can be made to pay on the basis on which I have been educated to consider things as paying." There were no records of that institution, so far as its internal operation was concerned, that were worth anything. Everything was reported, so far as the circuits were concerned, as being in fairly good order; but there were some defects, owing to the embarrassed condition of the company. They were running a blower and it could not be dispensed with, because of the liability of gas to accumulate in the conduit. Let it be there and we have an explosion. What is the cause of the explosion? Defect in the wires reported in fairly good condition, defects in the insulation causing a spark, and the spark causing an explosion. That does not speak well for the perfect insulation and perfect state of underground wire, and that was a sufficient reason for the continued expense of running a blower, and it was run. Further effort was made to ventilate the conduit and improve it. Then it was reported that there was no evidence of gas. We ran it probably five or six months with from 100 to 130 lights, on short lines. With the 100 to 130 lights the company did not pay its expenses. I am only mentioning this now to show you that there was no financial success in that particular instance. I will also say that there were more than six explosions in the ducts. Nothing having happened to seriously injure the property of the company, the record was not kept very closely, but after the condition of the conduit was reported to me as being in such a shape that there was no liability to these explosions, we had one. That was got out of very cheaply. We settled the damages for, I think, $260, and I considered that we were fortunate. Now, that is the history of the Philadelphia company which Mr. Johnstone quotes, and the only thing that he has to quote. I did what I think any man in this convention would do. I went to the directors and told them we could survive under this thing with an object in view, but the chances of pecuniary remuneration would not justify taking the risk. They followed my suggestion, and we abandoned the arc light business of the station. We were not in incandescent business, but we had that elephant on our hands; what were we going to do with it? I suggested taking up incandescent lighting on a small scale to see if we could get some knowledge of our own out of that experience. A given amount of money was appropriated to enable us to put in a small incandescent plant and run it. The amount of money expended directly in that one object exceeded by a few hundred dollars what I estimated it; but two and a half times as much was spent for what I had no idea would arise in expenses. We found the whole of these conduits from one end to the other were broken and smashed up so that we could not get anywhere through them from accumulated gases, caused by defective insulation. Two and a half times as much money was required to be spent before we could put into anything like decent operation our experimental incandescent station. That station was always run at a loss. I had no interest at stake there except to make that station successful. The capital of that company is $500,000; it was blocked out for one hundred lights; there remains in the treasury of the company a little more than half the stock.

Now as to the comparative cost of operating wires underground or overhead: Leave out the question of rented conduit, I make this statement here that the cost of maintaining overhead circuits from one station running about eleven hundred lights, exclusively on overhead wires for the year 1888, was eighty-two one-hundredths of a cent per lamp per day. In that I do not include the labor item. I have taken the labor of linemen, one-third of whose time is probably engaged on this particular work. It is 1.76 per cent of the cost of the lights. About fifty miles of that wire embraced in the maintenance account was put up in the summer of 1881, and not five miles of that wire has been abandoned or replaced. It is just as good to-day as it was when put up. In this whole system of subway conduits the electric light company have had sufficient experience to make them cautious. They want a reasonable assurance that a thing will be successful and give them a fair return before they put in their money. In Philadelphia to-day the arc light business is practically at a standstill because of this agitation on the subject of overhead wires. Philadelphia is practically stopped in the extension of its business; New York has stopped in the extension of its business on account of the subway question. The business here in Chicago, I will assert, is infinitely smaller than it would be if the light companies had the facilities for running their wires overhead, and so it is all over the country. Now the business in Philadelphia and in New York in proportion to the demand for it is a picayune business.

Mr. F. Ridlon, of Boston—We have had one difficulty in Boston with the underground service, which does not seem to have been touched upon at all. We were very much surprised a few weeks ago to have the insurance people intimate to us that they would have to increase our insurance, because of electric lighting, as they considered it an extra hazardous risk. We felt that it was necessary to know the reason of it, as they had heretofore expressed the utmost confidence in electricity and considered it the safest method of illumination. We got the representatives of the insurance companies together, their experts and their inspectors, and the electric light people, and their statement was that there had been within the past six months a large increase in fires in the city of Boston, occasioned by electric light wires. We investigated each case, and found that a very large proportion had been caused by the underground service, which had been in operation about one year. The amount of underground wire was some forty or fifty miles We have nearly 600 miles of overhead wire in Boston; two or three hundred miles of it has been in operation about six years. The alarming increase of these fires has been within the past eight months; they caused large losses, whereas in the previous five years of overhead lighting insurance companies had not paid one dollar of loss on account of electric light fires. It finally proved that in nearly eight out of ten of these fires they were caused by the underground service, and it is now a question whether we can afford to continue the service which was found to be an extra hazardous risk.

Mr. Weeks—I would like to read a couple of letters from two electricians who are well known not only in America, but throughout the world. The first is from William Hochhausen, of New York, addressed to the editor of the Kansas City *Globe*. The second is from Professor Elihu Thompson. Mr. Weeks then read the following letters:—

NEW YORK, Feb. 6.

To the Editor of the Globe:

In relation to the question of the feasibility of using underground conductors, it must be confessed that very little experience has been had, as yet, with such conductors for the convenience of high-tension arc light currents. Chicago has probably been wired underground for such purposes to a larger extent than any other city in the United States. These installations are of such recent date that it would be premature to pronounce them an assured success. It would seem advisable to watch the working of existing underground circuits for a few years before attempting to enforce burial of a great number of circuits. If roomy, well ventilated subterranean passages were provided for the reception of the electric wires by the municipalities it might be possible for the arc light companies to give satisfactory service, but such structures are very expensive, and would certainly be beyond the means of electric light companies. A wire, merely buried, when insulated as well as our present knowledge of insulating substances will enable us to do, would be liable to give trouble and necessitate the repeated digging up of the streets to effect repairs. The overturning of the soil in city streets will generally cause miasmatic exhalations, and should be prevented as much as possible. It seems that New Orleans will shortly try a system of running wires at a very high elevation, fastened to substantial iron structures placed at street intersections. This plan is likely to prove very successful. This undertaking should be watched with interest by all corporations contem plating a removal of pole lines.

WM. HOCHHAUSEN.

LYNN, Mass., Feb. 10.

To the Editor of the Globe:

It is difficult to formulate any opinion which will apply, without exception, to every instance of wiring. While considerable objection can undoubtedly be urged against the use of overhead wires, particularly as they are frequently installed in electric signaling, telephone and electric light work, objections may also, with equal force, be raised against any system of subways thus far put down. Without doubt the most satisfactory subway arrangement would be to have a sufficiently large tunnel for the passage of workmen, with means for supporting the wires on the sides and roof, thorough ventilation of the subway being always maintained. This would be, however, enormously expensive in most cases, and except for the main thoroughfares of a large city, the expense may be considered to be prohibitive. The difficulty is not so great in dealing with the wires in the main streets, which probably could be put underground whenever the expense was not too great. But the real difficulties are met in minor ramifications which would be needed to reach customers at various points.

The problem of preserving the insulation of underground wires which are exposed to emanations of the soil, leaks of coal gas, steam, etc., is in itself a serious one, particularly with high potential currents, such as are in use in arc lighting. There would seem to be no reason whatever why telephone and telegraph circuits might not be put underground in suitable subways, and the expense would be very much less in proportion than in the case of electric light wires. This would remove a very large portion of the overhead wiring, and also that portion consisting of bare wires and innumerable dead wires of telephone and other circuits, as it frequently does not pay to take down a wire when it becomes disused. This is not the case with electric lighting wires, which are not liable to become dead wires at any time, and which, when grounded or defectively supported, at once give notice of the fact by causing trouble in the system. Most of the crosses and leaks on electric light circuits are without doubt caused by the frail, uninsulated, rough surfaced wires of telegraph and telephone systems falling down upon the electric light wires.

It is my opinion that legislation would succeed best in the undertaking of removing the overhead wire nuisance, for such it undoubtedly is, by a gradual process, first getting those wires underground which can without doubt be put there with an increase of security and certainty of service, as in the case of telephone and telegraph circuits within the limits of a city. What wires are then allowed to remain overhead should be taken care of by enforcing a system of skilled supervision in the placing of them, prohibiting the irregular and random

running of wires from point to point and requiring that an orderly system or plan should be observed, the purpose of which would be to keep the wires together and to allow branches and crossings only at right angles, on neatly constructed and well supported structures. It should also be required that a sufficiently large and strong wire be used so as to resist the action of wind storms and sleet storms.

I think that in many instances the enforced resort to subways, especially such as might be and such as have been constructed by parties having little acquaintance with the nature of the problems to be solved, such as subway companies securing a franchise for such work, and proceeding on such an economical basis that poor construction and unskilled supervision are made to take the place of first-class work, would be a damage to the business of electric lighting, and would, in fact, act as an insuperable barrier to the undertaking of business in quarters which cannot be reached cheaply and easily by overhead construction; in many cases subway construction requiring an outlay which would far more than counterbalance any return from the business itself would be necessitated.

The remarks I have made apply particularly to large cities. For towns of very moderate size I can see no reason why overhead wiring, properly looked after, properly organized and systematized, would not be comparatively free from objections, while the expense of construction of subways would be so great as to render electric lighting or telephone work worse than unremunerative. The location of subscribers and users of telephones and electric lights are apt to change from time to time or from year to year, and this is particularly the case in the smaller towns. Oftentimes the different users are at considerable distances apart, and changes of location often would involve the giving up of portions of a subway or underground wire system, and would in this way lead to greater losses of capital. In the denser part of cities this objection does not hold good, because of an average sufficiency of users or consumers in such districts.

Oftentimes, in order to make a business a success, even in cities of dense population, it would be necessary for an electric light company to secure contracts for a period of years, as in this way only could it be guaranteed against loss in the installation of a system of wiring, involving the introduction of underground lines which, to be placed, would require the digging up of the streets, etc.

I am, however, heartily in accord with any measure which does not deal with this case of overhead wires blindly, but takes up the question in a fair-minded spirit, with a clear-sighted judgment of the difficulties of the undertaking. A continued experience tends to confirm me in the opinion that the proper way to deal with the question is to first dispose of those wires which can be buried without detriment and without prohibitive cost, which action would be followed by the gradual elimination of others wherever it is feasible and where the circumstances are such that this can be done without destruction of business interests involved. A plan of reorganization of the wiring under strict rules as suggested above would, I think, suffice for the remainder of the overhead work.

When this is done our cities would be free from the immense tangle of wires covering the streets and buildings, passing from point to point in every conceivable direction, vertically, horizontally and in every other way, which wires have been installed at the caprice of linemen whose only desire has been to get through their task as quickly as possible, and who in fact may have been urged to work in this manner by their employers.

ELIHU THOMSON.

Mr. T. Carpenter Smith then offered the following resolution :—

"*Resolved*, That the thanks of this association be tendered to the committee on Underground Wires for its endeavors, and the chair continue the committee and add to it Mr. Sunny, Mr. Sperry and Professor Barrett, with a view of obtaining further information, and that the sense of the association is, that it is not yet in a position to make any recommendation for or against the placing of arc light circuits of over one thousand volts potential in underground conductors. The resolution was seconded by Mr. Ecclesine.

Mr. Cooper offered a substitute as follows :—

The National Electric Light Association does not feel that the experience of which it has knowledge is of such a nature as to justify it in believing that any practical commercial method of putting high tension arc light wires carrying a current of over a thousand volts underground has been brought to its attention. The substitute was seconded.

Dr. Moses—Seven companies have replied to these inquiries. The fact is that only one city in the country has looked into this thing carefully. In view of these facts I think it would be better for us to stay any action on this subject till we have more experience. When you are quite sure that you have a system by which electric light wires can be buried, then put them down.

Mr. Morrison—It is perhaps unfortunate that so few experiments have been made in underground lines by those engaged in the electric lighting business. I regret the personal turn that these discussions have taken, but I believe that this is one of the most important subjects which we are called upon to face, and that we cannot keep it down. I think the convention owes a debt of gratitude to the gentlemen who have composed this committee and have done the best they could. Mr. Smith, of Philadelphia, who always brings to every subject he considers a degree of intelligence not surpassed by any member of this convention, has given you a full and broad statement from his standpoint, and that is the standpoint of experience. There is, however, a point in his statement which needs to be carefully considered. He said he had had no experience with high tension arc lights. The experience given by Mr. Smith, while it is good as far as it goes, does not cover the domain in which many in this association have invested their money, and to whom capitalists are looking for a return of the money invested. A subject of this kind cannot be fairly considered nor properly passed upon in a day, much less in the time allowed us to-day. This convention is banded together for the purpose of obtaining from year to year such information as the experience of its members can suggest. We are not expected to frame perfect laws or give information which is infallible. I think it was in 1874 or 1875 that I was superintendent of the fire alarm telegraph of Baltimore. I was directed by the council of that city to report upon the feasibility and probable cost of placing the wires underground. I had correspondence with every country on the face of the globe where underground wires had been used. An exhaustive report was compiled. I was able to report that it was perfectly feasible to place such wires underground, and the cost at which that work could be done at that time in Baltimore was named. The conditions which govern the laying of telegraph and telephone wires and those which govern electric lighting are entirely different; but no one has ever heard me say that it is not feasible to put high tension electric light wires underground. On the fifth day of the current month I received a letter from the editor of the Kansas City *Globe*, asking me whether, in my opinion, any satisfactory system had been invented, and whether arc electric lights could be placed in a subway with telegraph and telephone wires, also if high pressure electric light companies would be compelled to discontine business if the underground wire law went into effect. To those questions I made the following reply :—

BALTIMORE, Feb. 11.

It is, in my judgment, possible to construct a subway and to make it available for high as well as low tension systems of electric lighting. Such a subway, however, has never been constructed in this country. The efforts in that direction, notably in New York and Chicago, have succeeded only in crippling the electric light service, preventing the general public from reaping so fully the benefit from it as when the lines are permitted to be used overhead. The demand for subway construction comes, in a general way, from legislatures and citizens who know little or nothing about its requirements or defects. Intelligent legislation cannot be had unless the legislators possess this knowledge or take sufficient time and make sufficient expenditure of money to possess it. For this reason all experiments in this direction should be made at the expense of those desiring it. It is, therefore, my opinion that all subway construction should be done at the expense of the city or state, and when by them completed should be submitted to competent judges as to their availability for the purposes intended. Then introduce the wires in a limited way, that experience may prove the correctness of the system, after which order private companies to place their wires in each conduit, charging sufficient rental for the same to cover cost of maintenance. I say cost of maintenance, not any part of the cost of construction. It is my opinion that neither municipal nor state governments should invade the domain of private enterprise for the purpose of making profit. The citizen has greater stake in the untrammeled use for electricity for light and power than he has in the investment necessary to take the current underground. If this course is adopted by the legislature of Missouri or any other state, it will not "cripple the arc light companies using high pressure," nor will it "lead to the abandonment of these enterprises."

J. F. MORRISON.

That about covers the ground from my standpoint. I have been familiar with every effort in this direction, and consider the work done in Chicago as perhaps the most intelligent of any experiments in the United States. The result is told by Mr. Sunny. He has shown you that the subway system in Chicago is not perfect, and the tremendous cost of it. I believe those evils can be remedied and some plan found by which the lines may be carried underground. Until that time comes, no body of men, state legislatures or others, have a right to put their hands in your pockets or mine and take from us the result of our labor and invest it in a plan which lessens their taxation and imposes a double burden upon us.

I look to such men as Professor Barrett and Mr. Johnstone and the men who are engaged in the manufacture of insulated cables for the solution of this question.

The question upon the resolution of Mr. Cooper was then put, and a vote taken by roll call.

During the calling of the roll, when Mr. DeCamp's name was called, a separate vote was recorded for him as the representative of four different companies. The question whether he had the right to more than one vote provoked some discussion, and was settled by Mr. DeCamp withdrawing three votes.

The substitute was lost. The question recurring upon the original resolution of Mr. Smith, Mr. DeCamp offered an amendment, adding to the resolution the following words :—

"*Provided*, however, that the passage of this resolution shall be without prejudice to the resolution passed at the meeting held in New York in August last, until a further report is made by that committee."

The amendment was lost by a vote of 31 to 37.

Mr. G. H. Roe, of San Francisco, offered the following substitute :—

"*Resolved*, That while the appliances and devices for operating electric light wires underground are being continually improved, and promise ultimately to render practical the operating of all electric light wires underground, they have not yet reached such a degree of perfection as would justify this convention in declaring itself in favor of underground wires for central station arc lighting."

The amendment was lost by a vote of 31 to 39.

Mr. Morrison moved that the resolution be laid on the table and made a special order for 12 o'clock, February 21. The motion was carried.

The convention then adjourned until the following day, Thursday, at 9.30 A. M.

THURSDAY'S PROCEEDINGS.

The secretary read a letter addressed to President Duncan by David J. Harris, manager of the electrical exhibition of the St. Louis Exposition and Music Hall Association, stating that an extensive general exhibition would be held at St. Louis, commencing on or before September 4, 1889, continuing for a period

of six weeks. It was stated that it was intended to make the electrical exhibition the finest ever held in the country. The letter continued :

No charge will be made for power or space to exhibitors who are members of your association, and ample accommodations will be made for such exhibits. It is expected that articles for this exhibition will be shipped to St. Louis and returned for one half the usual rates. The St. Louis Exposition and Music Hall Association cordially invite the National Electric Light Association to meet at St. Louis during the time of this electrical exhibition. The exhibition building occupies four large blocks, cost $700,000, and contains two halls, the larger having a seating capacity for 5,000 persons. The smaller hall, known as Entertainment Hall, which is fitted in the finest style, will be placed at your disposal, in which to hold your convention, free of charge, including all the necessary service, light, heat, etc. Ample hotel accommodation will be provided at very reasonable rates.

The communication was received and filed.

The following gentlemen were elected to membership upon the recommendation of the Executive Committee :—E. G. Acheson, S. A. Barton, C. F. Dunderdale, H. H. Eustis, A. R. Foote, N. D. C. Hodges, W. J. Johnston, Philip Lange, George M. Phelps, R. F. Ross, C. M. Ranson, Fred. H. Whipple, David Stinton, John Kilgore, A. D. Bullock, W. A. Kreidler, J. P. Barrett, Timothy W. Sprague, G. L. Austen.

Mr. Sunny, chairman, read the report of the Executive Committee, as follows :

REPORT OF THE EXECUTIVE COMMITTEE.

At the meeting of the association held in August last at New York the following resolution was adopted :—

"*Resolved*, That this association shall hereafter have a permanent office in the city of New York, which shall be in charge of an expert electrical engineer, who shall be secretary and treasurer of the association ; that the president at once take steps to secure the services of such a person, and establish him in suitable headquarters, and with suitable facilities, in this city."

The president, acting on the instructions contained in the above resolution, appointed Allan V. Garratt, of Boston, secretary and treasurer of the association at a salary of $2,000 per year.

The Executive Committee, at a special meeting called in Pittsburgh, November 19th, unanimously ratified the appointment and indorsed the action of the president. The Executive Committee has examined the financial report made by the secretary, and the work that he has been able to accomplish during the past four months. It is entirely satisfied with the results that have been obtained, and unanimously recommends that the office in New York be continued for a further term of six months. While the committee is not unanimous in the opinion that an office in New York can be maintained unless the membership is very largely increased, it is entirely willing to have the experiment tried for six months more, and is very hopeful that the secretary will be able to make the office so successful as to justify its continuance indefinitely. On the occasion of this convention the Executive Committee has striven, at the suggestion of a number of people, to make an electrical exhibit that would represent as fully as possible the electric light and power service.

As has no doubt been observed, many of the manufacturers have gone to a large expense to make the display both complete and instructive. It was decided that in justice to the exhibitors a larger attendance of persons to view the exhibit than was represented in the association ought to be assured, and the committee, therefore, has sent out about 50,000 invitations, addressing them to persons connected with the management of the large industries and the educational institutions. So far the attendance has been of a character that is encouraging both to the committee and the exhibitors, and everything points to the accomplishment of the result aimed at, namely, the educating of the general public in the progress in electrical development.

Mr. A. F. Mason, of Boston—The report recites that at a meeting in Pittsburgh the action of the president was confirmed, and names a date somewhat subsequent to the opening of the office in New York. If I am at liberty to, I would like to know, whether the provision was made by the Executive Committee for the payment of the salary of the secretary from the time when these quarters were opened.

Mr. Sunny : Yes, sir, it was.

The report of the Executive Committee was adopted.

Mr. Steuart—It is necessary for us to-day to elect officers for the ensuing year, and I, therefore, move that the house now go into a committee of the whole for the purpose of nominating officers.

The motion was carried, and the president appointed Mr. Steuart chairman of the committee.

COMMITTEE OF THE WHOLE—NOMINATIONS.

The Chairman—The first thing to be done in preparation of the work of the Committee of the Whole, is to request all those who are not active voting members of the association to retire from the room. It is necessary to do this in order that we may transact this business. It has to be done with closed doors ; we shall be very glad to see all visitors as soon as the committee rises.

Mr. W. S. Hine, of New York—I beg to nominate for president of the National Electric Light Association for the ensuing term, Samuel A. Duncan, of Pittsburgh.

The nomination was seconded.

Mr. Duncan—Mr. Chairman, while I feel grateful for the compliment paid in the nomination, I rise to decline most emphatically. You have honored me with the position of president for the term of one year. I feel that the action of this association to-day in the report, which has been made to it by its Executive Committee, showing the financial status and condition of the treasury of the association and the work accomplished in a very short space of time, is such that it needs no word from me to justify the wisdom of the association in establishing a permanent headquarters in charge of an electrical engineer as secretary and treasurer. I have no personal ambition to gratify; I have no enemies whom I desire to punish and no friends to reward. My desire has been from the very first to put this association upon a higher plane, and believing that that was the proper way and the only way by which this association could come to a higher and better standing, I suggested that policy. Whether it is right or wrong, time will develop, and I have no doubt that in the hands of the gentleman, whoever he may be, whom you select for your president, an honest, fair, straightforward trial of this officer will be had, and whether it shall demonstrate the wisdom or unwisdom of the course, the trial will vindicate the effort of the association to do what it started out to do. Thanking you for all the courtesies you have extended the chair, I decline the nomination.

Mr. M. J. Perry, of Providence—Four years ago, amid much boisterous tumult without and some little trouble within, in this city, in the month of February, was born the National Electric Light Association. Present at that time, earnestly working, willing ever to put aside anything that might affect him personally for the good of the association, was a gentleman who is with us to-day, and has been with us at every meeting of the association, one who has been careful and thorough in all investigations, conservative in all his conclusions, honest and conscientious in all his convictions—that gentleman is known to you all—I nominate him for president of this association for the ensuing year—Edwin R. Weeks, of Kansas City.

Mr. Weeks's nomination was heartily seconded by Mr. De Camp, Dr. Moses and Mr. E. A. Maher.

Nominations for the presidency were then closed.

Mr. Cooper—For first vice-president of this association I have to propose to this association the name of a gentleman who has long been associated with it in all its work. I nominate Mr. A. J. De Camp, of Philadelphia. Mr. De Camp's nomination was seconded cordially by Messrs. Cooper, Ridlon, Cram, Beidler and Mason.

G. A. Redman, of Rochester, nominated Mr. E. A. Maher, of Albany, for second vice-president, and was seconded by Mr. C. C. Curtiss, of Cleveland.

H. M. Daggett, of Attleboro, Mass.—I would like to submit a list for members of the Executive Committee of the ensuing year. I would nominate B. Rhodes, of Niagara Falls ; B. E. Sunny, of Chicago ; George A. Redman, of Rochester ; C. R. Huntley, of Buffalo ; Dr. Otto A. Moses, of New York ; E. T. Lynch, Jr., of New York ; P. H. Alexander, of Boston ; J. F. Morrison, of Baltimore ; and T. Carpenter Smith, of Philadelphia.

Mr. C. A. Brown, of Chicago—I would move that the same ticket be nominated, with the substitution for the name of Mr. Sunny, of Charles R. Faben, of Toledo. In doing this I want to state that my object is to have the Executive Committee consist entirely of central station operating representatives, or at least of those men representing current companies, so-called. We should exclude from the Executive Committee all who are engaged in the supply business or in the manufacturing business. Another reason for substituting Mr. Faben's name for that of Mr. Sunny is that Mr. Faben not only has a large electric light plant, but also is a representative gas man. The gas men have on many occasions given membership to electric light men. I do not think the electric light associations have extended equal courtesies to the gas men. Mr. Faben is not known to most of us, I presume, but whoever does know him will know him to be a whole-souled genial man. He expected to be here at this convention, and hoped to be, but sent his regrets. He is a member of the association, and I hope that his name will be placed on the Executive Committee.

Dr. Moses—Mr. Brown has spoken of the necessity of the Executive Committee being composed of men who represent central stations. That has been in my mind. I, myself, do not represent such an institution, and yet I think that this association should be composed, not only of men who represent stations, but all other interests in which electricity plays an important part. Nevertheless, it is my sincere conviction that the ultimate success of this association depends upon its guidance by those who are interested, and who represent central station lighting. Now, this association, as I understand it, has been formed for the purpose of bringing together those employed in central station lighting and other branches of electricity, and those who furnish supplies. It has been successfully done, and I hope that both of these inter-

ests will recognize at once their due position. I, myself, come in somewhat in an intermediate capacity. If it is the opinion of this convention that only one of these interests should be represented upon the Executive Committee, I feel as if I should respectfully withdraw my name from it.

T. Carpenter Smith, Philadelphia—I feel a little modesty in rising to speak on a nomination for the Executive Committee, having myself been nominated, but I think it due to the convention to state what I think would be for its best interest, and what I think we will all of us realize in a short time, and that is, the extreme value of Mr. Sunny as a member of the Executive Committee [applause].

Mr. S. A. Duncan—I nominate Mr. F. A. Cheney, of Elmira, N. Y., as a member of the Executive Committee.

Mr. Morrison—I cannot sit silent and see the possibility of having drift from your active service in the cause of the association, a man so conspicuous for his interest in all electric lighting matters as Mr. B. E. Sunny. The perfect appointments of this convention, the vast labor necessary to bring about the condition which you see before you, and all that appertains to it, while due credit must be given to all the electrical people of Chicago, including the chief of the municipal electrical department, yet he with whom we have been brought directly in contact, and with whom we have served on the same committee, has demonstrated his great fitness for the place, to which he has been nominated. The objection made by Mr. Brown is in the main a valid one, and yet, on the Executive Committee, Mr. Sunny is the only exponent of a system that sooner or later we will be compelled to face; that at each convention will be brought up before you, and that I hope to see settled; that some provision will be made to place every electric wire under the surface of the ground. Mr. Sunny has had the handling of an underground plant in Chicago. I, for one, believe in going to the shop to get shop information. I believe that, to have the best results, this association must be brought in touch with those who handle the specialties by which they carry on their business. I believe that the manufacturers of apparatus, the manufacturer of cables and insulated wires, and those who are spending their time and their money in endeavors to bring about the best plans of placing wires underground, are all valuable aids and adjuncts to this association, and without them, your meetings twice a year would be comparatively valueless.

Mr. Mason—The reason stated here for the motion to drop Mr. Sunny and to introduce another name is an outrage to one-half the members; men who do not want any office, but who are told substantially that they can pay their dues and exhibit their goods, but they must understand that they are not of the association, that they are an outside element. If this association is an electric light association, such language ought not to be permitted. If this association is an association of central station plants, let it be so, and be called so. I earnestly hope that Mr. Sunny's name will be retained on the committee.

Mr. Brown—In making the amendment which I offered, I had several reasons why it was more proper, as I thought, for me to make that motion than for any one else to make it; and in stating those reasons I think I will explain to Dr. Mason what, it seems, has rather touched him, that I am not a central station man. I am not a man engaged exclusively in selling electric light lamps, but the business of the company which I represent covers not only manufacturing electric light apparatus, but also dealing in supplies. Therefore, I thought that it was particularly appropriate that the expression of opinion which I have heard frequently—not on the floor of this convention, but outside—should come from a man who represented various interests. Another reason why I thought that such a motion was proper as coming from me, was because, I am personally acquainted with Mr. Sunny, and it would be understood by every one, I think, that there is no personal objection in my mind to Mr. Sunny. It was simply a matter of policy that I wanted to introduce here. Another reason was, that I was on the nominating committee at New York; I was chairman of that committee, and it was my own motion that Mr. Sunny should be appointed on the Executive Committee and made the chairman of that committee, a position which he has filled to the satisfaction of every one. Another reason was that, in a conversation which Mr. Sunny recently had with me, he said his determination—not his desire, but his determination—was never to serve on the Executive Committee again, and rather laid blame on me for getting him into the position that he had occupied so far. I make these remarks in explanation of my amendment to the original motion.

General discussion followed, during the course of which Mr. Brown withdrew Mr. Faben's name.

The question being on the nomination of Mr. F. A. Cheney for a place on the Executive Committee, the nomination was lost by a vote.

A resolution to adopt the nominations of members of the Executive Committee as first made, was then put and carried unanimously.

The Committee of the Whole then rose, the president resumed the chair, and the association received the committee's report on nominations as follows:—

President: E. R. Weeks, of Kansas City.
1st Vice-President: A. J. De Camp, of Philadelphia.
2d Vice-President: E. A. Maher, of Albany, N. Y.
Executive Committee: B. Rhodes, of Niagara Falls; B. E. Sunny, of Chicago; C. R. Huntley, of Buffalo; Dr. O. A. Moses, of New York; E. T. Lynch, Jr., of New York; P. H. Alexander, of New York; J. F. Morrison, of Baltimore; T. Carpenter Smith, of Philadelphia.

The report of the Committee of the Whole was postponed.

The Chairman—The next business, according to the special order, is the resolution of Mr. Smith, namely:—

"That the thanks of the association be extended to the committee for its endeavors, and that the chair continue the committee on Conduits and Conductors, and add to it, Mr. Sunny, Mr. Sperry and Professor Barrett, with a view to obtain further information, and that the sense of this association is that, it is not yet in a position to make any recommendation for or against the placing of arc light circuits of over 1,000 volts potential on underground conductors."

Mr. T. C. Smith—I rise to speak upon this motion, because, I think it right to explain exactly what I wish to accomplish by that motion. I am afraid that I have been misunderstood by the very men whom I wish to benefit—the central station men. I have already had brought to my attention very forcibly within the last year that this association has been getting the name of a packed body of men to oppose underground wires. The moment that attitude is taken by the public, that moment the central station men find this association of no earthly use to them, but rather a detriment. I introduced that resolution that this convention of this National Electric Light Association might come before the public as a body of men who were willing to consider any question fairly and justly, to examine into it with all the skill and knowledge at their command. I had hoped that the report of this committee coming before us showing the distinct disadvantages of underground wires would enable us to say to the public, "Gentlemen, we are doing the best we can to gain information, and we are honest minded and upright enough to tell you as to the report handed in directly against underground wires that we are not yet in a position to say anything for or against it." I made the resolution in all honesty of purpose, and I am very sorry to say that I have since learned that it has been used to foment trouble between the central station men, and the supply men. I introduced the resolution for the best good, as it seemed to me, of the National Electric Light Association. I ask the unanimous consent of the convention to withdraw that motion, and I would ask that some central station man who is distinctively a central station man should present it to the convention.

Leave was unanimously given to Mr. Smith to withdraw his motion.

Mr. Morrison—In order to dispose of this matter in the way which will bring the best results to the National Electric Light Association, I beg to offer the following resolution:—

"*Resolved*, That the report of the Committee on Conduits and Conductors be recommitted to that committee, and that Messrs. Sperry, Barrett and Sunny be added to the committee, and that the committee be continued.

The motion was carried unanimously.

The report of the Committee of the Whole on nominations of officers was unanimously adopted, and on motion of Mr. Morrison, the secretary was authorized to cast the ballot of the association for the list of officers and Executive Committee as reported by the Committee of the Whole.

Mr. Morrison moved that the next place of meeting be Niagara Falls, at a time in August which shall be designated by the Executive Committee.

The motion of Mr. Morrison was adopted unanimously.

Niagara Falls selected as the next place of meeting.

Mr. S. E. Barton, of Boston, then read a paper on "Electric Light Stations as Fire Risks." (See page 94.)

Mr. Morrison—I want to call attention to that part of this able paper in which reference is made to the lamentable condition of many of the electric light stations of this country, to the occupancy by electric light companies of old tumbled down buildings. This is doing more harm to the electric light business than all its antagonists put together. The one declaration made in that paper, that the insurance companies of New England have been compelled to abandon the risk of electric light stations, is a sufficient warning to all those about to engage in that business; that the only proper course to pursue is to erect substantial stations under intelligent supervision, and that a law ought to be passed in each state, where electric lighting is proposed, placing such construction under the supervision of the government.

Mr. Barton—It is a pity to see what I believe to be one of the safest of risks that we can have at the present time, through no reasonable excuse whatever, in such a condition that insurance companies will not touch them as a general rule. I believe that in our business generally about 25 per cent. of the loss may be charged to what is known with us as moral hazard. I hold that this 25 per cent. should be eliminated from the electric lighting

hazard; there is no moral hazard. Therefore, I say when we can have a class of risks with that one risk entirely wiped out, it does seem a shame that we cannot have the class so raised as to make it desirable for insurance companies at low rates. The matter is receiving considerable attention now in New England, and only recently, the electric light committee, of which I am the chairman, has been asked by the New England Insurance Exchange to formulate a schedule for the purpose of making tariff rates upon central stations. Heretofore it has been done by the various committees, and has been out of the control of the electric lighting committee. They have been rated at what we call the flat method of rating without any regard to the real merits or demerits of the risk. We are now undertaking to formulate a schedule in which we shall assume a standard model risk at a very low rate. We shall then add for any deficiency a special charge—for those features which we believe contribute to making a central station a poor risk, and which can be eliminated by changing, and it will be largely in the method of construction, internal as well as external, of modern fire appliances and of the arranging of switchboards and things of that kind. We hope in a very short time to get a schedule formulated, whereby electric light people can have some idea of what we, as insurance men, think should be done in order to improve your risks, and that will be put into general operation in New England, and I hope it will spread. I know for certain that New York state and that the New York city associations will adopt it as soon as we have issued it, and therefore it looks as though the insurance of central stations in the eastern part of the country was in a fair way to reach some sort of a solution; but still it lies in your hand, gentlemen, to make it what it should be.

Dr. Moses—I have in my hand a pamphlet that has been sent to me, and I understand it has been extensively distributed throughout the United States. I will not comment on it, beyond merely reading its title, "The Comparative Danger to Life of the Alternating and Continuous Electric Currents." I have read this, but I will not lay before you the criticisms that this gentleman makes before the body now assembled. Those criticisms are not worthy of notice, but I have a resolution here which I think can express our views and which I would like to see adopted:

"WHEREAS, A certain individual, in order to gratify a personal resentment, has, in exaggerating the dangers of electric currents, striven to influence legislation so as to cause the introduction of electricity in the form of alternating current as a means for the infliction of death on condemned criminals, therefore, be it

"*Resolved*, That the National Electric Light Association earnestly protests against those efforts, and unanimously resolves that the members of this body decline to allow any electric current under their control to be used for ignoble purposes."

Mr. Phelps—If in order, I move that the resolution be laid on the table. I think we had better ignore the pamphlet entirely.

Mr. Steuart—I have to offer a resolution which I am sure you will all accord with, and that is, that we tender to Mr. Barton the thanks of the association for the very excellent paper he has read for us, and that it be accepted and placed upon file among the records of the association.

Mr. Phelps—I withdraw my motion and will renew it afterwards.

Dr. Moses—I beg to suspend the resolution I offered in order to pass the resolution by Mr. Steuart, in which I most heartily concur.

The resolution of thanks to Mr. Barton was unanimously adopted.

Mr. Phelps—I renew my motion to lay Dr. Moses's resolution on the table. My opinion is that it would be very unwise for us to pass this resolution. We probably could not better please the author of that book than by passing the resolution. If we disapprove of it we can do it best by silence. That is my view, but I will not argue it now, because you all want to go to dinner.

Dr. Moses—I will beg to state for that reason I did not state the name of the individual, but the efforts are there. It is quite unnecessary for us to know the name of the man who shoots an arrow at us in the dark if it hits us.

Mr. Phelps—I think it would be better to withdraw the whole matter.

The motion to lay on the table was put and lost, and Dr. Moses's resolution was adopted.

The convention then took a recess until 2 o'clock P. M.

THURSDAY AFTERNOON.

The President.—The first business in order this afternoon is the report of the committee on the New England Exchange and the discussion of Mr. Barton's paper on insurance.

Mr. P. H. Alexander.—I am not the chairman of the committee, but I was requested by the chairman to bring before you this matter of the New England Electric Exchange. I have not prepared a written report, but as the secretary of the exchange wisely put in some numbers of its paper which contains a stenographic report of the proceedings, I may, with its aid, make the object of the exchange well understood.

In March of last year there seemed to be a great deal of dissatisfaction expressed as to certain insurance rules pertaining to wiring, and in order to see how the electrical fraternity stood on this matter I prepared a circular which, in common with other gentlemen in the business, I have sent around to every station superintendent and station company. The circular reads as follows:—

Comments having been made by electric light people regarding the rules issued by the Insurance Exchange for regulating light installations, it seems desirable that the representatives of electric light companies and superintendents of central stations should meet the electric light committee of the Insurance Exchange and their inspectors, to talk over equitable means for harmonizing the object of insurance inspection and the effect of installation of electric light plant.

The circular then goes on to call a meeting at a certain time. There was quite a large attendance at the meeting which followed, about sixty or seventy gentlemen being present. A number of electrical matters were discussed, and it was finally proposed to form an organization to be called the New England Electric Exchange, which should be, so to say, a mediator between what then seemed to be conflicting interests. The organization was completed by the choice of officers, and right here let me say that in that organization only manufacturing companies and electric light companies were to be admitted to membership. The call read as follows:—

Every one actually engaged in manufacturing or installing electric light and electric power apparatus, or in operating commercially an electric light or power plant, will be eligible to membership of the exchange.

This meeting was held on the 2d day of April, and a constitution was adopted, and also a plan of licensing. The exchange took the ground that the insurance companies could not help reduce insurance where electric light installations were made perfect, and you have heard Mr. Barton's paper this morning, which states that he acquiesced in that. We took the ground that electric light was the least dangerous artificial illuminant, but we took the ground that electric light plants should be perfectly well installed, and therefore we proposed to license—and we have done so since—employés of electric light companies operating electric light, and employés of wiring companies. The result soon shows itself. In less than six months from the time that the organization was started, the insurance companies of their own accord made a reduction in insurance rates on all buildings and manufacturing establishments where electricity was used as the only illuminant, a reduction of 10 per cent. on incandescent, and 5 per cent. on arc light plants. The prime object always has been to look for good work. Manufacturing companies and operating companies alike had a common interest to have good work done. Lately some trouble arose in the city of Boston regarding fires that were said to have occurred there from electric wires, and the board of underwriters of the city of Boston proposed to adopt more stringent rules. We invited them to meet with us and the tariff committee of the Boston Fire Underwriters' Union and the electric light committee of the New England Exchange and the inspectors of the Insurance Exchange, and, in common with them, we discussed this matter, and as a consequence this circular was issued Feb. 1.

To Electric Light and Wiring Companies:

It has been decided by the Boston Fire Underwriters' Union that on and after March 1, 1889, they will not approve underwriters' wire for electric light wiring in any manner inside of buildings. Moisture-proof and water-proof wire must be used. All loops, or drops, from poles or other outside structures, to and into buildings, must also be of a heavy moisture-proof insulation. It must first be submitted to the electrical inspector for his approval. This rule applies to all new work, also to any change made in old work. Parties who have made contracts for wiring calling for underwriters' wire, which contracts will not be completed before March 1, 1889, must send a written notice to the electrical inspector of the Boston Fire Underwriters' Union. If such notice is not given, the work will not be approved under any circumstances. Any contract made subsequent to this notice, and not strictly complying with these rules, will not be approved.

At a meeting of the Underwriters' committee, held Jan. 28, 1889, it was voted that on and after May 1, 1889, all electric lighting and wiring companies' men, who are in any way responsible for any of the wiring, running of dynamos, or care and management of batteries for electric lighting, must hold a license from the New England Electric Exchange. This rule applies to isolated plants and central stations alike, and is imperative. No exception to it will be made.

OSBORNE HOWES, JR., Secretary.

I read this to you to show how harmonious are our relations now, that a year ago seemed to be antagonistic. The plan of licensing has further been approved since by the legislature, who have incorporated this exchange and given it power to grant licenses. In order to promote ambition in excellence of workmanship and to extend the knowledge among men practically engaged in installing and operating electrical plants, and thus make it an object for fire underwriters to recommend the introduction of electricity in preference to other means of producing artificial light and power, the New England Electric Exchange will issue licenses of five classes, each class representing a certain extent of qualification. First-class licenses are issued only to persons fully competent to install and operate any electric light or electric power plant. The applicant for a first-class license must be able to make working plans for central stations and for isolated installations, must have a general knowledge of the construction of dynamo-electric machines, and the electrical appliances necessary for electric light and electric power installations, a general knowledge of the principles, construction and installation of secondary or storage batteries, a thorough knowledge of the insurance rules pertaining to the business, a specific knowledge of the system operated by the applicant, and a thorough knowledge of the calculations necessary for and the rules governing electric wiring, and be able to make complete wiring plans. From this class

we go down to those requiring less and less knowledge to men who are not competent to do the electric work. Fifth-class licenses are issued to persons competent only to operate electric machinery, and who are not competent to do electric wiring. The applicant for a fifth-class license must have a general knowledge of the operation of the particular electric light or electric power machinery it is desired to operate, and a thorough knowledge of the insurance rules pertaining thereto. "Who were your examiners and who examined your examiners?" as one man put it to me. Well, we have in New England a good many good electrical men. We had Mr. Anthony and Mr. Hill, of Boston, on practical work. We generally take three men to work together, two of whom would be good practical men and one having a good knowledge of theory. These gentlemen have to serve right along, without pay. I want to say that in order to make this a success it was necessary for about twenty-five of us to give half a day each week to this business exclusively—to devote themselves to this matter at a loss; but they have done it. We have now six examining boards composed of three each, and we have five directing boards that meet every Monday. Every safeguard was put, however, around the issuing of licenses. These examiners would examine the applicant who made application for a certain class. How few of them obtained it the last official report, which dates now some months back, will show. I find that forty-three men applied for first class license and only twenty-six obtained it; of forty-five who applied for second-class only thirty-one were successful, while forty-two men who had applied for higher class licenses received only a fourth class. But they were quite satisfied, and we have a great many letters from them saying, "We simply go ahead and will try again." They have in several cases brought to the second examination a great deal more knowledge, having something to look forward to and to attain. After the examiners have gone through and made their minutes of the examination, they send their report to the board of directors, who weigh the matter carefully and either send the report back if not in accordance with rules laid down here or accept it. Before issuing these licenses each examiner has to sign the certificate that is issued. The president and secretary have to sign the certificate, and then once more we send it to the insurance inspector of that district, who comes in personal contact with these men, and who can tell us if, while they may have a knowledge of the business, they may be careless in carrying out their work. We have also a clause by which we can revoke any license that has been given to a man who proves incompetent afterward or careless in his work. Now, your resolution last summer asked this committee to recommend to the National Electric Light Association what means should be taken to attain the same object. I have given this matter thought only a couple of days, but I cannot see how the National Electric association can establish a plan unless they divide the United States up into sub-districts or recommend state organizations. I want to say before I sit down that Mr. Barton's paper this morning, as well as the remarks I have made, would probably be best supplemented if the president would grant the New England insurance inspectors who are present here, but not members, the privilege of the floor.

The Chairman—We shall be glad to hear from Captain Brophy.

Captain Brophy—If the New England Electric Exchange fulfills its promise half as well as I hope it will, the office of insurance inspector will be no longer necessary. The insurance people of New England perhaps have taken a more intelligent view of the electric light matter than most any other body of insurance men. There is no antagonism between the two bodies, but the insurance men stand sadly in need of enlightenment in regard to many points of electric lighting. When we have competent men in every station in New England ready and willing and taking a pride in doing their work as they ought to do it, the sensational newspaper of the day will have one less theme. Now, it is very difficult to secure a fair share of insurance on the best-equipped electric light stations in the best companies. In New England we have had scarcely any loss to speak of, when the amount of property invested in electric light stations is taken into consideration; but we are met with the fact, I suppose, that they do have severe losses outside of that territory. We have just now blocked out a schedule of rating for electric light companies, and I trust that this organization will assist us a little. All now that is required of you gentlemen is to do what you know how to do, and see that it is done—to make fires caused by electric lights or electric light wires so scarce that they will hardly ever be heard of. I wish to correct one statement made here yesterday which should not go abroad, because it is not strictly proved. It was true that a little while ago the insurance people of Boston were somewhat agitated over the frequency, as they thought, of small fires in that city, caused, or said to be caused, by electric light wires, or by electric lights. I regret to say that this feeling in the breasts of insurance men was largely engendered by electric light men themselves. It will not do for you to run down or decry your opponents or competitors, as it will appear to the average insurance man that all systems of electric lighting are unsafe. Bear in mind that when you make them believe that one system, because it is not the one that you are dealing in, is unsafe, they naturally conclude that the same rule applies to all. Now, that was fomented in that way. It was stated here that every one of these fires was caused by underground wires. That is not true. The fires in New England, unfrequent as they have been, have not been confined to any one particular system of electric lighting; they are equally distributed among different kinds, or among different systems; but happily they have been so few that very little or few losses have had to be paid.

After remarks by Mr. Killicut, of Boston, on the same subject, on motion of Mr. Morrison, the report of the committee on New England Electric Exchange was accepted, and the committee continued. The thanks of this convention were extended to Captain Brophy and Mr. Killicut.

Mr. C. H. Rudd then read a paper on "Disruptive Discharges in Lead Cables." (See page 92.)

Mr. Acheson—Mr. Rudd has given me much pleasure by the paper he has prepared. My original experimental work was done with the object of eliciting replies and drawing others into this work—a work that must be done by somebody, and a work that I have but few facilities for doing. But I have here a few notes of some work that I have done during the last week. There were two questions, I believe, which Mr. Rudd said that the matter turned on—either I was demonstrating or had discovered a new principle, or else it was all wrong. I do not think I discovered a new principle and I do not think it is all wrong; but he seems to think that I have assumed an increase of energy, owing to the existence of the cable. That is not exactly the case. We have though, owing to the fact that the cable is there, an energy on hand that is not contained in the dynamic current, and it is that that produces our discharge; and following that up in a very limited way, I find for instance, from experiments, that the time necessary for the formation of an induced current on opening a primary—the induced current being a secondary—is the twenty-five hundred thousandth part of a second; that a current is of quite sufficient length and more than sufficient to produce a spark. The time necessary for the spark is about the eight-millionth part of one second. Now we have here the amount of energy contained in or represented by the dynamic current in two hundred feet of a No. 6 Brown & Sharpe wire conductor, when conveying a current of two amperes. That will have for each second of time, passing under that wire, an energy equal to eight and two-tenths joules, and the amount of energy that may be withdrawn from such a conductor under such conditions in the space of a twenty-five hundred thousandth of a second, or the time occupied by the induced current will be two five-hundred-thousands of a joule. Now the amount that can be withdrawn in an interval of time equal to twenty-five hundred-thousandths of a second will be four-tenths of a joule. Now the energy contained in the same sized cable under similar conditions and operated by two thousand volts of current, the energy there will be equal to four one-hundredths of a joule, or about twenty times the amount of energy that can be withdrawn from the same length of cable, owing to the existence of a dynamic current in the cable. Mr. Rudd assumes that I have supposed an increase of energy or a building up. It is a building up, or rather it is a condensation, you may term it, owing to that capacity, and it enables us to do about twenty times that work. Some experiments I made were in relation to the time necessary for a discharge on the more remote parts of the cable. I wanted to learn how the distance from the terminal would effect this discharge, and although I have lost my notes, I have roughly jotted down some of the data from memory. My experiments were made with wire No. 18, Brown & Sharpe. There were fifteen feet of wire through which I could discharge a current that was held in a jar having a capacity of twenty-five ten-thousandths of a microfarad, and charged up to its potential, so that it would discharge through two hundred and eighty-six thousandths of an inch. With that amount of energy discharged through that wire I produced an induced current in a parallel wire and used that as a means of determining the time or rather the rapidity of change in the inducing current affecting directly the electromotive force in the parallel wire. With a wire ten feet long—my parallel wire was about five feet in length—I could get a discharge between the terminals of the terminal wire of one hundred and fifty thousandths of an inch. As that wire lengthened to twenty-five feet the discharge became about seventy-five thousandths of an inch—I have forgotten exactly—and it fell to about forty thousandths at one hundred feet. From there on the curve flattened out, and at two hundred feet it had not dropped probably below thirty-five thousandths. Now, from this I rather argue that the first one hundred to one hundred and fifty feet is the portion of the cable that is going to effect this discharge. The other portions beyond that cannot deliver their energy with sufficient rapidity. It shows the necessity of the energy being delivered instantly, in a time far beyond any measurement of ours—in the eight millionths of a second. Now, if Mr. Rudd will kindly permit me to use his diagram, I would like to say something further. This is the diagram showing the apparatus first used to determine the electromotive forces of these various sections of the conductor, and also the required electromotive force with any given condenser or capacity for this discharge. Now, as I stated, my experiments

at this day were hardly begun. I had not yet learned the true cause of this, and the fact of the necessity of explaining it does not detract, I should think, from the existence of the results. They still exist, regardless of the fact of any necessary explanation which I, at that time, did not have, but which afterward has been partly shown. The length of this wire [indicating] was certainly a few inches. I have forgotton the lengths. In fact I did not at that time appreciate the necessity of measuring them, but they were probably perhaps four or five feet. Now I have just shown that five feet of wire lying parallel to a primary wire receive and induce current sufficient to discharge through fifteen one-hundredths of an inch, and we know that a current induced in a parallel wire is not as great as that induced in a primary, in case the secondary is absent. The current in the primary is the greater of the two. So that when we open this, we have here a charge in this condenser, and on opening this our electromotive force drops and the condenser will tend to discharge back [indicating]. It will induce a current here, but owing to the opening here [indicating], it has set up a self-induction at this point that will be sufficient to close across. That is a possible explanation, and it is not one that I absolutely assert is true. It is only in a condition of study with me. I am not through with it and I am glad to have the assistance of any one who is willing to join in the work.

But Mr. Rudd did not draw attention to the existence of the condenser in this diagram. He referred to the fact that opening this switch lengthens this distance. How he supposed that I in any manner attributed the opening of that and the necessary increase of this to the production of a spark, I cannot understand.

Mr. Rudd—Pardon me, Mr. Acheson, didn't you do your first work without the condenser?

Mr. Acheson—Yes, I find that I did; but I believe that I attributed that to the capacity of the circuit. I actually gave the capacity of the circuit as the four hundred thousandths part of a microfarad, and that this part, without the other condenser, was due to the capacity of the circuit. In no case did I consider it without the capacity; for, though I sometimes tried with the expectation of not getting it, I still found it in the circuit.

Mr. Rudd—I would say right here that I took the ground that if capacity was at all necessary to make the spark plain, the capacity then was a primary condition and not merely an auxiliary condition, and I understood that you examined the auxiliary effect of condensers, or the effect of the condenser upon disruptive discharge. Where a tendency to discharge already exists you desired to find out how much that was increased by the presence of the condenser.

Mr. Acheson—Of the condenser and of the energy it delivers at the disposal of the work to be done. In the paper read in New York I believe I stated that there was no time for the generation of a current in the dynamo. You had to have it on hand. As I have shown here the actual energy transmitted over your wire is but a fraction of that on hand, owing to the existence of your cable and its capacity; it is a thing you must have there to do the work with. The current passing over the wire is not sufficient to generate it.

But referring to this diagram here, Mr. Rudd simply stated the case very clearly, as I explained, I believe, from the fact that when there is a spark here, we get a spark there [indicating]. If it was understood that I stated that it was owing to the actual existence of the arc, which I may have done without intentionally doing so, I wanted to have it understood that it was due to the fact of the arcs having existed, or existing, as the case might be. It was either due to the fact of their existing and preventing the discharge passing through the arc or to the fact that they ceased to exist and there wasn't time for the circuit to close, leaving an open space prohibiting the discharge from passing in there, and consequently it passed here [indicating].

Now, I would like to state here that while I was in the early stages of these experiments, I thought that I had already at that time obtained results of value to those who were interested in underground work, and that they would be benefited by knowing of these results and profiting by them. An invitation was sent to a gentleman interested in underground matters very extensively, to come and see these experiments, in order that he personally might profit by them. That gentleman returned to his home and introduced the subject to various others, and they entered the experimental field with a decided desire, as has since developed, to obtain results contrary to those which I had obtained, and which had been offered to him gratuitously for his special benefit. This work is some of the results of it, and this is one of the experiments made at that time [referring to the diagram]. Here we have a piece of cable placed in our circuit. The experimenters have taken a condenser and connected one of the terminals to the line wire. The statement was not made as to distance between the end of this cable and the point on the line where this terminal was connected. But having done this, they obtained a spark on making a contact with the terminal and the cable, which would not surprise them, provided the distance between these points was of any value. After doing this they connected the ends and got a discharge that certainly would not have produced the beliefs or theories that I had formed. There will under certain conditions be a different value obtained, as was shown by the fact that when the cable was dry they could not get a charge of much value. When it got wet, they did get a charge of more value. When it got wet, this cable, instead of remaining a conductor simply parallel to the line wire, became more or less grounded throughout its entire length, and in place of getting your potential at any point here which is produced by the line wire, that point would be removed a certain distance. But, however that might be, your charge could be of any value governed by the distance you would carry your point back toward the machine.

Mr. Rudd—It was two or three inches.

Mr. Acheson—Then it would be dependent on that, and your grounding of the cable would throw that point back still farther.

Mr. Rudd—If you will pardon me, I think it carried it to the other side of the dynamo.

Mr. Acheson—Then you would get the entire charge of your machine in it.

Mr. Rudd—We got a very decided charge considering the resistance of the field.

Mr. Acheson—That diagram, (figure 6) is figure 5 (see pp. 93, 94), changed in its connections, and neither of them has any relation whatever to determining the value of a discharge, owing to the current condensed in the cable. In your first two hundred feet of cable, the interval of time necessary for your current to be delivered and discharged to your terminal is greater than that occupied by your spark. But then, in your first two hundred feet your energy is of greater value than that obtained in the dynamic current in a similar range of wire.

The President—I desire to take the opportunity now of formally introducing to you our new president, Mr. E. R. Weeks, of Kansas City [applause].

Mr. Weeks—I have too deep a sense of the high honor that you have conferred upon me to fail to doubt the wisdom of your choice. Although my home is very near the geographical centre, it is some thousand miles west of the electrical centre of the United States. In view of this fact, and knowing that you have many members much better qualified to fill the office of president of this association, I take your action in large part as a recognition of the great west, as a recognition of the sleepless enterprise and indomitable pluck that is rapidly converting the great American desert into green pastures, blooming orchards and fields of golden grain, and which have transformed a vast swamp into one of the world's greatest and most beautiful cities. This association now enters upon its fifth year, and while much has been accomplished under the able leaderships of Mr. Duncan and Mr. Morrison, infinitely more remains to be done. The electrical industries lead the van of human progress. In the highest sense of the word the electrical engineer of to-day is the resultant of all engineering experience, and to the engineers of the world more than to all other professions the civilization of the present age is due. Let us remember our high calling, and with one accord strive to advance the National Electric Light Association to a still higher place among the world's industrial and scientific societies. Gentlemen, in accepting the trust which you have placed in my hands, I ask you to give me your counsel, your sympathy and your most hearty support [applause].

Mr. De Camp offered a resolution as follows:—

"*Whereas*, in no state, so far as can be ascertained, are the laws properly drawn to enable municipalities to contract with incorporated companies to perform services for cities and their citizens upon a sound economical basis; be it

"*Resolved*, That a committee on state and municipal legislation be appointed, consisting of one member from each state, to operate together, to secure such legislation in each state, as may be required to enable municipalities to contract with incorporated companies to perform services for cities and their citizens, on the sound economical basis of securing to such companies an undivided demand, an unrestricted privilege and a permanent investment."

The resolution was adopted.

Mr. Mason—This calls for the appointment of a committee of one from each city. I move that that be referred to the executive committee.

The motion was carried.

The following papers were then read:

"Fuel Oil," by Mr. S. S. Leonard. (See page 95).

"Liquid Fuel," by Mr. M. J. Francisco. (See page 96.)

"Advantages of Oil as Fuel," by Mr. C. N. Ransom. (See page 98.")

Mr. Leonard—We are pioneer users of oil in the northwest. The question of insurance is the only bugbear with us at present. The other troubles we think we have overcome. As I stated, to comply with the requirements of the insurance companies would make the use of oil almost prohibitory. Mr. Francisco states that by the introduction of air pumps for creating a vacuum, making a complicated apparatus, and by the placing of your tanks fifty feet away from your building, you can use it. I believe that oil can be used under a gravity pressure with as much safety, if not more so, than by pumping it. He quotes the Springfield, O., fire as being an example of feeding by gravity. I had a short conversation with the manager of that station not long since, and I was especially interested, as just before leaving home, the insurance

agent informed me that a policy was canceled. I asked why: "They will not insure because you feed by gravity." I asked the Springfield manager what his arrangement was. He stated that his tank was underground, and also under the building; that his supply tank was above ground, holding, I think, twenty-four barrels or thereabouts. An oil pump was used to pump the oil from his tank cars into his storage tank, and also into his supply tank. The supply tank was an upright tank, and on the top of it was a man-hole, which was left open at times. The pumping of this oil stirred it up more or less, and created a great deal of gas. The gas escaped from this man-hole, and the building was filled with it. The oil, as Mr. Francisco said, overflowed and came out through this manhole. Gravity had nothing to do with it. It overflowed and ran over the floor to a lighted lantern. The only thing that surprised me was that he had not burned up long ago. He had a regular fire trap there. Now, I claim that the use of oil should not be condemned by insurance companies because one man has it put in by a very poor arrangement. We have a capacity of about 26,000 gallons in two tanks; they are eight feet in diameter and thirty feet long, placed underground, about twenty-five feet from our building, walled up on the side, imbedded in solid masonry and arched over at the top with brick. We have a space between the two tanks about six feet, giving plenty of room for a man. We have valves at the opening of the tanks where the oil is admitted to the supply pipe and can be cut off there; at the entrance to the building there is another valve where it can be cut off; as it flows along the supply pipes there is another valve before it gets into the building, making four valves before the oil reaches the burner.

Mr. Lockwood—The company which I represent in Detroit have been using crude oil since the first of July last continuously. We feed by gravity.

Now, the manager of one of the largest insurance companies came to our plant and examined it thoroughly. He was under the impression that the pressure system was the only safe one; but he changed, his mind and said that he would recommend in the future that the gravity system be employed, and with a small tank which furnished the oil limited to one barrel per boiler per hour, and that would give capacity enough.

Our plant is different in one respect from any that has been spoken of, inasmuch that the large tank, although under the ground, is within one foot of our building, and we are right in the heart of the city of Detroit. And still as close as we are to other buildings with the capacity that we have there, the insurance company only charges us 20 cents additional rate. Mr. Francisco spoke of a case where the tank had overflowed by gravity and caused a fire. If that had been arranged as we have ours arranged in Detroit, that would have been an impossibility. We feed from the large tank under the ground to the upper one by means of a pump, and the pipe is only a one-inch pipe. We have from the upper tank returning to the lower a three-inch overflow pipe, and the three-inch overflow pipe will carry more oil than the maximum capacity of the pumps. Second, if the oil is allowed to rise too high, it can do nothing more than return to the tank from which it is pumped.

We also have connected with it one other safeguard, that is, the pipe feeding the oil from the small tank to the burner is connected at the level of our floor with the overflow pipe returning to the large tank with a cock-opening valve, so, in the event of fire, if this valve is opened in less than two minutes every bit of oil in the building within the small pipes will be thrown back to the large tanks.

Mr. Francisco—I have been inspector and general agent and adjuster of insurance companies for twenty-five years. That was my business until I took up the electric light business; in fact, I am in it now. I have consulted nearly every one of the prominent companies of the country in regard to these points that I have developed in my paper. The insurance companies' managers have told me that if the electric light folks would adopt the plan I have proposed they would insure them, but if they did not, they should charge them as I have specified.

Now, Mr. Leonard's use of valves is all right. But the point comes just here. There are always a lot of fools around electric light stations, the same as everywhere else so far as fire is concerned; and your station may have forty valves, but what good would it do to men situated in the other part of the building?

In the case in Winsted, Conn., where they used petroleum oil, the station burned up awhile ago. The insurance was paid. They were burning oil at Winsted and they fixed everything up in first-class shape; they had steam pressure where they forced the oil from the vertical pipe; then they had an escape pipe for blowing out the sediment that always gathers in pipes, and a drip valve or drip pipe running down from that to take out the sediment. In that case they had forty pounds of steam pressure on that pipe that was forcing that oil on these burners. What does that man do? He unscrews that cap to let out that sediment (there was forty pounds pressure upon it), and the result was he had a two inch stream of oil, and anybody can tell what would be the result. That case was reported in the papers as an explosion of gas.

Just before I left home, I offered the risk to the agent of one of the biggest companies in the country, on my own station, which he declined, saying he would not write it at any price. "Well," he said, "to be candid with you, we don't know anything about it; therefore, we take the safe side and refuse." I took him through the station and explained the whole *modus operandi* to him, and I showed him the paper that I have read here. He said: "I want you to send a copy of that paper to our company, and we will investigate this matter, and if you will send it to the Insurance Exchange, and we will investigate it; and if the electric light folks wish to meet us, we will meet them at any time and have a committee appointed to study this whole matter." Now, there is the basis of what you want to do. My suggestion is that this association appoint a committee to meet a committee of the insurance companies to investigate this matter and put it upon the proper basis, and enlighten them upon this subject of electric plants.

Mr. Lockwood—I stated a few moments since that our insurance in Detroit was only increased 20 cents per $100, and what I now add is this: That when we put in our crude oil plant our insurance was very nearly expired. It did expire about three months since, and I have since renewed it, and renewed it at the same rate, and the result is that in the insurance, with the exception of paying at the rate of 20 cents more for $100, I have no trouble now in placing our insurance as well and as easily as I did before.

The Chairman—A motion has been handed up providing for the reconsideration of the motion to continue the committee on the New England Electric Exchange, passed this afternoon.

The motion was reconsidered.

Mr. Morrison offered a resolution, that a committee of five be appointed, with Mr. P. H. Alexander, chairman, to recommend a tax by some means that would secure to the National Electric Light Association the advantage now enjoyed by the New England Electric Exchange regarding the pleasant business relations between the electric interests and the insurance interests, and report at the next meeting of the association.

The motion was carried.

Mr. Alexander C. Chenoweth then read a paper on "Conduits; Their Material in Relation to Insulated Conductors." (See page 99.)

Mr. F. H. Whipple read a paper on "Municipal Lighting." (See page 100.)

Mr. A. R. Foote, of Cincinnati, read a paper on "Municipal Ownership of Commercial Monopolies." (See page 102.")

Dr. Moses, of New York, offered the following resolution, which was unanimously adopted:—

"*Resolved*, That the thanks of the National Electric Light Association be and are hereby tendered to the St. Louis Exposition and Music Hall Association, through David J. Harris, manager of the electrical exhibit, for the very cordial invitation of Feb. 19th for this association to hold its next convention in St. Louis, and the very generous offer of the use of Exposition Hall, and of free exposition space for convention purposes, and, be it further resolved that it is with regret that the association is obliged to decline the invitation above named."

Mr. Morrison moved the reconsideration of the action by which the resolution for the appointment of a committee on state and municipal legislation was referred to the executive committee, in order that the appointment be made by the chair.

The motion was seconded and unanimously agreed to.

The Chairman—The chair will appoint upon that committee, under the resolution of Mr. Morrison in regard to the New England Exchange, Mr. Alexander, chairman, and Messrs. Francisco, Cram, Woodbury and Perry.

Mr. Mason, Boston, offered the following resolutions, which were unanimously adopted:—

"*Resolved*, That the hearty thanks of the National Electric Light Association are hereby tendered to the Exposition society for the valued courtesies extended by it to the association during its present sessions.

"*Resolved*, That the National Electric Light Association desires to record its grateful appreciation of the valued and able services of B. E. Sunny, chairman of the executive committee, who, by the exercise of rare executive ability, has so largely contributed to the success of the meeting in Chicago."

Mr. Mason also offered the following resolution:—

"*Resolved*, That a committee of five, of which Mr. Arthur Steuart shall be chairman, be appointed, whose duties shall be to report at the next session of the association a plan for the incorporation of this body."

The motion was lost.

The Chairman—If there is no other business before us, the chair desires to return his thanks to you for the courtesy and consideration you have extended to him, and to say that he will give to his successor all the support he is capable of during his new administration. If there is no other business, I declare this convention adjourned, *sine die.*

EDISON'S INCANDESCENT LAMP PATENT ANNULLED IN CANADA.

A special despatch from Ottawa, of March 7, announces that Commissioner of Patents, Pope, of the Dominion of Canada, has rendered a decision annulling Edison's patent No. 10,654 of November 17, 1879, for incandescent electric lamps, on the grounds of importation and non-manufacture in Canada beyond the statutory limit of time. Under the statutes of Canada no appeal lies from this decision, which must be regarded as final. The proceedings arose originally upon a petition filed by the Royal Electric Co., of Canada, against the Edison Electric Light Co.

OUT OF ORDER?

A valued correspondent sends us the following note and enquiry :—

Much time and earnest discussion were devoted to the consideration of the report of the Committee on Underground Conduits and Conductors, at the recent Convention of the National Electric Light Association. The report of this committee seemed to be unsatisfactory to a majority of the members present. Why, then, was it "accepted?" After it *was* accepted, why was further action taken, which was contradictory to the action taken by the Convention in "accepting" the report?

Can it be that Mr. Morrison and other astute parliamentarians, were ignorant of the simple rule which is thus stated in Roberts' Rules of Order?

"When the assembly is to consider a report, a motion should be made to 'adopt,' 'accept,' or 'agree to' the report, all of which, when carried have the same effect, namely, to make the doings of the committee become the acts of the assembly, the same as if done by the assembly without the intervention of a committee."

THE EDISON FILAMENT PATENT SUSTAINED IN ENGLAND.

On the 18th of February, Lord Justices Cotton, Lindley, and Bowen, of the Court of Appeals delivered judgment, reversing the decision of Justice Kay, of the lower court, and sustaining the validity of the Edison English patent of November 10th, 1879. This is the second reversal of judgment in the course of the long litigation of the case, Justice Kay's decision last year being in reversal of an earlier one. An appeal still lies to the House of Lords.

REPEAL OF THE TELEPHONE RATE LAW IN INDIANA.

THE Indiana Legislature has repealed the act of four years ago, fixing a maximum charge for telephone service within the state. The question of rates is thus left to contract between the telephone companies and their subscribers. The business community of the state, it is understood, have been much dissatisfied with the situation during the past four years. The Central Union Telephone Co., whose business covered the greater part of the state, closed many of its exchanges soon after the passage of the law of four years ago, maintaining service on a toll system in the larger towns. The toll system was satisfactory neither to the public nor to the company. The Central Union company will now reorganize its Indiana business on its former basis. The experience of Indiana in limiting telephone charges by state legislation ought to give pause to the promoters of similar acts now pending in a number of states.

CORNELL UNIVERSITY.

ANNUAL INSPECTION TOUR OF ELECTRICAL AND MECHANICAL ENGINEERING STUDENTS.

The electrical and mechanical engineering students of Sibley College, Cornell University, will make the annual spring inspection tour during the coming vacation. They will start March 22d and return April 2d or 3d. The coming tour will be divided into four distinct trips; two west and two east. The western route taken by the electrical engineers will include Rochester, Lockport, Niagara Falls, Buffalo, Pittsburgh and Cleveland. At Rochester they will inspect the electric light stations and isolated plants, and at Lockport a visit will be made to the Cowles' Electric Smelting Co.'s works and the city light and power stations. They will then spend the Sunday at Niagara Falls and continue their journey on the 25th, taking in the Buffalo electric light stations and isolated plants. At Pittsburgh a visit will be made to the Westinghouse Electric Co.'s Works, the Standard Underground Cable Co.'s Works, the Faraday Carbon Co., and to other industrial establishments of interest to electrical engineers. The party will make a study of the electric railways of Pittsburgh and Alleghany, and at Cleveland will inspect the works of the Brush Electric Co. and National Carbon Co. The evenings will be spent at the various electric lighting stations. The eastern trip will include Albany, Troy, Schenectady, Yonkers, New York city, Brooklyn, Newark and Orange, N. J. The electrical engineers of the eastern trip will inspect the Edison Machine Works, Eickemeyer Works, Julien Station, Daft Works, Excelsior Works, various lighting stations of New York city, and the Metropolitan Telephone Exchange. A visit will be made to the laboratories of Mr. Edward Weston and Mr. Thomas A. Edison. On Thursday, March 28, they will visit the New York Electric Club. The western trip is under the charge of Professor Edward Nichols, and the eastern under that of Professor E. P. Roberts. The whole tour is under the management of Dr. R. H. Thurston, and it is largely through his efforts that these annual inspection tours are made so interesting and instructive.

PERSONAL MENTION.

MR. GEORGE A. HAMILTON is about to sever his connection with the Western Union Telegraph Co. to enter the New York factory of the Western Electric Co. Mr. Hamilton's ability and attainments as an electrician are too well known to be mentioned at this time. The officials of the Western Union Telegraph Co. are reluctant to lose his services. Mr. Hamilton is to be congratulated on his new connection, which affords a wider scope for talent and activity than the electrical and testing department of the Western Union service.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Allegheny, Pa	Observatory Hill Pass. Ry. Co	3.7	6	Bentley-Knight.
Ansonia, Conn.	Derby Horse Ry. Co	4	3	Van Depoele.
Appleton, Wis.	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	12	Daft.
Asheville, N. C	Asheville Street Railway	3	4	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Binghamton, N. Y	Washington St., Asylum & Park R. R	4.5	8	Van Depoele.
Boston, Mass	West End St. Ry. Co., Brookline Branch	12	20	Sprague.
Brockton, Mass	East Side Street Ry. Co	4.5	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	5	8	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	8	Daft.
Cleveland, Ohio	East Cleveland Railroad Co.	23.5	16	Sprague.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenport Central Street Railway Co	3.5	8	Sprague.
Danville, Va	Danville St. C. Co	2	4	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co	8.5	12	Van Depoele.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	7	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Fort Gratiot, Mich	Gratiot Electric Railway	1.75	2	Van Depoele.
Harrisburg, Pa	East Harrisburg Pass. Ry. Co	4.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	2	Sprague.
Ithaca, N. Y	Ithaca Street Railway Co	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind	Lafayette Street Ry. Co	2.25	8	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angelos, Cal	Los Angelos Elec. Ry. Co.	5	4	Daft.
Lynn, Mass	Lynn & Boston St. Ry. Co.	2	2	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co	4.5	5	Daft.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co	4	12	Thomson-Houston.
Pittsburgh, Pa	Pittsburgh, Knoxville & St. Clair St. Railway	2.25		Daft.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Reading, Pa	Reading & Black Bear Ry	1.5	2	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Richmond, Va	The Richmond Union Pass Railway Co	13	40	Sprague.
Salem, Mass	Naumkeag Street Ry. Co	1.75	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
St. Catherine's, Ont	St. Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	9.75	13	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	5	10	Sprague.
Scranton, Pa	The People's Street Ry	10	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	4.5	10	Thomson-Houston.
Scranton, Pa	Nayang Cross-Town Ry	1.25	4	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	4	10	Thomson-Houston.
Syracuse, N. Y	Third Ward Ry. Co	4	8	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co	2.5	10	Sprague.
Washington, D. C	Eckington & Soldiers' Home Electric Railway Co	1.7	3	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	10	Van Depoele.
Wichita, Kan	Riverside & Suburban Ry Co	6	3	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	3.6	7	Sprague.
Wilmington, Del	Wilmington City Ry. Co	6.5	13	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	1.5	2	Van Depoele.

Total—Roads............ 59

" Miles...............303

" Motor Cars.......440

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Alliance, Ohio	Alliance St. Ry. Co	2	3	Thomson-Houston.
Atlanta, Ga	Atlanta & Edgewood St. Ry. Co	4.5	4	Thomson-Houston.
Atlantic City, N. J	Pennsylvania R. R. Co	6.4	6	Sprague.
Bangor, Me	Bangor Street Railway Co	5	4	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets			Bentley-Knight.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	20	Thomson-Houston.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cincinnati, O	Cinc. and Inclined Plane Ry	6.5	20	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Cincinnati, O	Cincinnati St. Ry. Co	2.7	8	Thomson-Houston.
Erie, Pa	Erie City Pass. R. R. Co	3.5	20	Sprague.
Hudson, N. Y	Hudson St. Ry. Co	2.5	3	Thomson-Houston.
Kansas City, Mo	Vine St. Ry		6	Thomson-Houston.
Kansas City, Mo	Metropolitan St. Ry. Co	2.25	8	
Lincoln, Neb	Lincoln Cable Ry. Co	5	10	Storage Batteries.
Louisville, Ky	Central Pass. R. R. Co		10	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co	69.5	8	Sprague.
Newton, Mass	Newton Circuit Line		10	Thomson-Houston.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3	6	Thomson-Houston.
New York, N. Y	North & East River Ry. Co	3	20	Bentley Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	5	7	Thomson-Houston.
Ontario, Cal	Ontario & San Antonio Heights Ry. Co	8	4	Daft.
Ottawa, Ill		6	8	Thomson-Houston.
Port Chester, N. Y	P. C. & Rye Beach Street Railway Co	3	5	Daft.
Richmond, Va	Richmond City Ry. Co	7.5	50	Sprague.
Rochester, N. Y	Rochester Electric Ry. Co	7	8	Thomson-Houston.
St. Louis, Mo	Lindell Railway Co		1	Julien.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Street Ry. Co	4	6	Sprague.
Seattle, Wash. Ter	Seattle Electric Railway and Power Co	5	5	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Southington, Conn		2.2		Thomson-Houston.
Springfield, Mo		2		Fisher.
Tacoma, Wash. Ter	Tacoma Street Railway	5	4	Sprague.
Topeka, Kan		14	30	Thomson-Houston.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.

Total—Roads............ 38

INVENTORS' RECORD.

Prepared expressly for The Electrical Engineer, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions,* 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From January 22, to February 12, 1889 (inclusive).

Alarms and Signals:—*Municipal Telegraph System*, T. J. Zoeller, 396,450. *Automatic Ground-Detector for Electric Circuits*, O. P. Loomis, 396,582. *Burglar Alarm*, A. C. Robbins, 396,667; G. B. Lehy, 396,701, January 22. *Electric Signaling Apparatus*, J. Young, 396,795, January 29. *Multiple Signal-Transmitter*, M. Martin, 397,194, February 5. *Automatic Alarm Apparatus*, E. Meyer, 397,657. *Electric Signaling and Alarm Apparatus*, W. L. Denio, 397,888, February 12.

Conductors, Indicators, Supports and Systems:—*Electric Wire Conduit*, J. Lynch, 396,407. *Underground System of Electric Wires*, H. B. Cobb, 396,543, January 22. *Insulating Pipe-Coupling*, S. Bergman, 397,218. *Junction-Box for Electrical Conductors*, W. M. Callender, 397,221. *Electric Wire Conduit*, W. B. Mack, 397,300, February 5.

Distribution:—*System of Electrical Distribution*, E. N. Dickerson, Jr., 396,-549. *Combination of Electric Generators*, E. W. Rice, Jr., 396,602. *System of Electrical Distribution*, E. W. Rice, Jr., and A. L. Rohrer, 396,603, January 22. *Electric Converter*, L. Gutmann, 397,461, February 5. *Regulating and Motive Device for Alternating Currents*, E. Thomson, 397,616, February 12.

Dynamos and Motors:—*Regulation of Alternate-Current Generators*, G. Pfannkuche, 396,422. *Dynamo for Telegraphic Purposes*, B. Gmur and O. Flatz, 396,557. *Coupling Dynamos*, O. P. Loomis, 396,580. *Coupling of Dynamos and Motors*, same, 396,581, January 22. *Device for Controlling Electric Motors*, H. H. Blades, 396,725. *Automatic Switch for Electric Motors*, G. H. Whittingham, 396,791. *Dynamo-Electric Machine*, P. Grant, 396,867. *Regulator for Dynamo-Electric Machines*, A. J. Holt, 396,932. *Armature-Winding for Dynamo-Electric Machines*, E. R. Knowles, 396,941. *Commutator for Dynamo-Electric Machines*, same, 396,942. *Regulator for Dynamo-Electric Machines*, J. F. Kester, 397,006. *Dynamo Electric Machine*, same, 397,007, Jan. 29. *Dynamo*, R. L. Cohen, 397,340. *Armature for Dynamo-Electric Machines*, O. B. Shallenberger, 397,392. *Dynamo-Electric Machine and Motor*, F. J. Patten, 397,439, Feb. 5. *Brush for Electric Generators*, R. Eickemeyer, 397,492. *Dynamo-Electric Machine*, R. M. Hunter, 397,550. *Regulation of Dynamos*, E. W. Rice, Jr., 397,613. *Electric Motor*, J. F. Denison, 397,702. *Method of Winding Field-Magnets*, T. A. Edison, 397,705. *Regulating Switch for Electric Motors*, H. H. Blades, 397,773. *System of Synchronizing Electric Motors*, F. J. Patten, 397,817, Feb. 12.

Galvanic Batteries:—*Electric Battery*, C. F. Heinrichs, 396,870, and 396,871, Jan. 29. *Galvanic Battery*, E. J. Colby, 397,111, C. E. Egan, 397,116, Feb. 5. *Method of Protecting the Negative Plates of Electrical Batteries*, F. J. Clamer, and J. G. Hendrickson, 397,489. *Galvanic Battery*, C. M. Thompson, 397,526. *Battery for Electric Belts*, W. G. Johnson, 397,806, Feb. 12.

Lamps and Appurtenances:—*Incandescent Lamp Socket*, O. P. Loomis, 396,583, Jan. 22. *Suspending Electric Light Lamps*, A. Siegrist, 396,897, Jan. 29. *Switch and Cut-Out for Electric Light and other Electrical Devices*, O. S. Bussmann, 397,109. *Incandescent Lamp Manufacture*, J. A. Vandegrift, 397,479, Feb. 5. *Automatic Switch for Electric-Arc Lamps*, E. R. Knowles, 397,729. *Electric Light Carbon*, H. S. Rheiner, 397,754, Feb. 12.

Measurement:—*Electric Meter*, M. J. R. Jacquemier, 396,403. *Electric Time Meter*, G. F. Card, 396,645, Jan. 22. *Revolving Photometer-Stand*, J. W. Packard, 396,951, Jan. 29. *Electric Meter*, H. H. Cutler, 397,538. *Telethermometer*, C. G. Hoffmann, 397,548, Feb. 12.

Medical and Surgical:—*Process of Making Dental Plates by Electro-Deposition*, J. G. Ward, 397,320. *Therapeutical Electrode*, L. T. Stanley, 397,474, Feb. 5. *Electro-Magnetic Attachment for Eye Glasses*, F. Fear, 397,790, Feb. 12.

Miscellaneous:—*Electrical Switch*, E. A. Sperry, 396,439. *Wiring Block for Electrical Circuits*, O. P. Loomis, 396,579. *Time Switch*, B. E. Waters, 396,632, January 22. *Electrically Operated Door Lock*, C. B. Beers, 396,723. *Electro-Magnetic Transmitter*, J. T. Williams, 396,792. *Tool for Splicing Wire*, H. G. Hubbell, 396,819. *Wire Hook*, P. Ashen, 396,847. *Electric Switch or Cut-Out*, E. R. Knowles, 396,880. *Electric Cut-Out Device*, J. C. Chamberlain, 396,920. *Automatic Electric Cut-Out*, E. R. Knowles, 396,940, January 29. *Hose Pipe*, E. H. Crosby, 397,171. *Electric Stop-Valve*, R. Wellens, 397,260. *Phonograph Recorder and Reproducer*, T. A. Edison, 397,280. *Electric Communicating System*, A. G. Holcombe, 397,364. *Protector for Electrical Instruments*, J. E. Crandall, 397,418. *Method of Demagnetizing Watches, etc.*, J. Greaves, 397, 423. *Connection of Electrical Circuits*, W. W. Griscom and H. N. Weidner, 397,424, February 5. *Electrical Stop-Motion Mechanism for Knitting Machines*, E. G. Conner, 397,537. *Electro-Magnetic Grain Scale*, W. A. Holley and U. Malin, 397,594. *Phonograph*, T. A. Edison, 397,706. *Safety Device for Electrical Circuits*, W. J. Hammer, 397,715. *Electric Switch*, A. E. Andrews, 397,826. *Method of Recording Speech*, G. H. Herrington, 397,956, February 12.

Railways and Appliances:—*Electric Railway Trolley and Support*, S. H. Short, 396,618. *Electric Railway System*, D. G. Weems, 396,633. *Turn Table for Cable or Electric Railways*, W. Davidson, 396,649, January 22. *Electrical Railway Signal*, W. P. Kookogey, 396,748. *Railway Signal*, same, 396,749 and 396,750. *Electric Lighting and Heating Cars*, J. F. Shawhan, 396,836, January 29. *Electric Railway Signal*, A. Z. Boda, 397,270. *Cable or Electric Street Railway*, W. S. Phelps, 397,385. *Overhead Contact and Switch*, C. J. Van Depoele, 397,451, February 5. *Electric Coupling for Railway Train Signaling*, W. C. Johnston, Jr., 397,558. *Apparatus for Heating Cars by Electricity*, R. M. Hunter, 397,857. *Overhead Line for Electric Railways*, F. J. Sprague, 397,875. *Electrical Railway-Gate*, M. Toulmin, 397,880, February 12.

Storage Batteries:—*Secondary Battery Charging*, C. F. Brush. 396,681, January 22. *Secondary Battery*, J. S. Sellon, 396,769, 396,770 and 396,958, January 29. *Method of Forming Secondary Battery Electrodes*, R. M. Hunter, 397,235. *Secondary Battery*, W. A. Shaw, 397,443, February 5. *Secondary Battery Plate*, E. R. Knowles, 397,557, *Process of Preparing Electrodes for Secondary Batteries* L. Paget, 397,607. *Electrode for Secondary Batteries*, same, 397,60°. *Secondary Battery*, W. Kingsland, 397,650. *Storage Battery Plate*, C. D. P. Gibson, 397,796, February 12.

Telegraphs:—*Sounder Attachment*, G. H. Carey and W. McArthur, 396,465, January 22. *Octuplex Telegraph*, M. W. Dewey, 396,734. *Railway Telegraph*, B. Cade, 396,983. *Railway Telegraphy*, same, 397,049, January 29. *Printing Telegraph*, A. T. McCoy, 397,466, February 5.

Telephones, Systems and Apparatus:—*Mechanical Telephone*, T. S. Davis and W. W. Davis, 396,688, January 22. *Telephone, or Analogous Electric System*, A. B. Ferdinand, 397,176. *Telephone Call Box*, A. Griffith and H. A. Burbank, 397,284. *Telephone Circuit and Apparatus*, J. A. Barrett, 397,331. *Telephone Paper Pad Holder*, J. B. Seymour, Jr., 397,472. February 5.

EXPIRING PATENTS.

Patents relating to Electricity which become Public Property in March 1889.

Reported for the Electrical Engineer, *by* F. B. Brock, *Patent Attorney,* 639 *F street, Washington, D. C.*

Magneto Electric Battery for Firing Fuses, etc., B. G. Noble. 124,216 ; *Telegraph Insulator*, M. G. Farmer, 124,199, 124,200, 124,201, March 5, 1872 ; *Lighting and Extinguishing Gas by Electricity*, J. Vansant, 124,773 ; *Electro-Magnetic Engine*, W. Wickersham, 124,868 ; *Telegraphic Recording Instrument*, T. A. Edison, 124,800, March 19, 1872; *Electric Belt for the Body*, J. E. Bazault, 125,006 ; *Electro-Magnetic Apparatus*, 125,078, March 26, 1872.

[Drawings and specifications of any patent will be furnished by Mr. Brock at cost, 15 cents each.]

THE

ELECTRICAL ENGINEER.

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EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers*

VOL. VIII. NEW YORK, APRIL, 1889. No. 88.

SECONDARY BATTERY LITIGATION.

THE decision of Judge Coxe in the case of the Electrical Accumulator Co. against the Julien Electric Co., elsewhere summarized, is important in its bearing upon the rights of the different concerns engaged in the manufacture of secondary batteries.

The contest as to who was the first inventor of the modern secondary battery, in which the active coating is applied mechanically to the electrode, began in the Patent Office in 1882. Chief among the claimants were Charles F. Brush, and Camille A. Faure. After a bitter struggle of four years, that tribunal declared Brush to be the first inventor, and patents were issued to him March 2, 1886, with broad claims for the invention.

The conflict was then transferred to the courts. The Brush Electric Co., the owner of the Brush patents, brought suit against the Electrical Accumulator Co., the owner of the Faure patent; the Electrical Accumulator Co. on its part, brought suit against the local Brush companies in New York; in Ohio against the Brush Electric Co. to repeal the Brush patents; and in the same suit the Brush Electric Co. filed an answer asking to have the Faure patent repealed. Besides this, both these companies sued the Julien Electric Co. for infringement of their respective patents.

The decision of Judge Coxe may apparently be regarded as practically settling all these controversies and clearing away this net-work of litigation. After an able and exhaustive discussion of the case, it is held that Brush was the first inventor of a secondary battery in which the active coating is mechanically applied to the electrode, but that Faure is entitled to a restricted claim for a battery in which the active coating is mechanically applied in the particular form of a paint, paste or cement. This claim of Faure's would seem, therefore, to be tributary to the broader claim of Brush, so that under this decision the Electrical Accumulator Co. may not be able to use even this particular form of battery without a license under the Brush patent.

In the case just decided, the Electrical Accumulator Co. sued upon four patents relating to secondary batteries—the Faure patent already referred to, two Swan patents, and a patent of Shaw & Rogers. The last named, however, was withdrawn and abandoned at the hearing. The two Swan patents are held by Judge Coxe to be invalid. The fourth claim of the Faure patent is also held to be invalid when construed broadly enough to be infringed by the defendants; while the first claim, the only remaining claim of the Faure patent sued upon, appears to be held to be invalid in its present form, for the reason that Brush is the first inventor of such a secondary battery. The Court states that if its owners will disclaim the broad invention, and will limit the claim of the Faure patent to a mechanically applied coating in the form of a paint, paste or cement, it will sustain this restricted claim and will grant that company an injunction and recovery under that claim.

The decision of Judge Coxe is of the more significance, because it is apparent that he has very carefully and thoroughly considered the most important of the vast mass of prior patents and publications and uses, relied upon by the Julien Electric Co. as anticipating the broad invention, and reaches the conclusion that the invention is not disclosed in any of them, and hence that Brush must be regarded as the first inventor of a secondary battery in which the active coating is mechanically applied to the electrode.

THE DOWNFALL OF THE COPPER RING.

THE month just closed has seen the collapse of the French monopoly of the world's supply of copper and the attendant ruin of the Comptoir d'Escompte, the great bank that tried to pull the Société des Métaux through its crisis. The rest of mankind may well feel some sympathy for the unlucky shareholders of the shipwrecked bank; but the members of the copper syndicate and all who took a hand in their gigantic "corner" will have to look only to the class of similar conspirators against the industries and commerce of the world for any commiseration in their losses. The American copper mine owners are said to be secured, in the main, for the copper they have furnished. It seems to be generally understood that, in addition to receiving a definite price from the syndicate, they were by agreement to get a portion of the profits of its operations. If that be true it would be gratifying to fair minded men to see them compelled to bear a corresponding part of such losses as may attend the liquidation of the syndicate's affairs.

The smash-up of the Société des Metaux leaves an accumulated supply of something over 100,000 tons of copper which must come upon the market. Apparently copper must fall below the normal price—the price regulated by demand and supply—and remain below it till the abnormal

stock be reduced to ordinary proportions. Meantime the production of the mines and smelting works will be reduced to hasten the arrival of a period of equilibrium.

THE bidding by the electric lighting companies on street lighting in New York, for the year beginning May 1, next, which took place March 27, illustrates a side of the subway question that has not been sufficiently regarded, at least by the public. Nearly every company tendering asked about twice as much per lamp on routes where they would be compelled to put their wires into subways as they did on pole-line routes.

Prominent members of so cautious and wary a body as the National Electric Light Association have on several occasions declared that the only obstacle to underground service is the cost; and when Mr. Carpenter Smith, at the recent Chicago meeting, held up to view a full pocket-book as a sample of insulation that would meet any strain whatsoever, he expressed the exact situation of the whole matter. Any desired insulation will be forthcoming if you will pay for it. So with conduits; a satisfactory subway is feasible if undertaken on broad enough plans and with sufficient money. In the present situation the electric lighting com panies find themselves compelled to incur large expense for underground conductors and to pay considerable sums for rental of conduits. The public should understand that if it insist on underground wires, it must pay at least part of the inevitable cost.

Two or three subway man-hole lids projected aloft by an explosion of gas and flying over people's heads in Madison Square, a few days ago, were a somewhat startling reminder that underground conduits may be quite as hazardous to the public as overhead wires, if not properly cared for. This sort of thing was predicted and has happened several times already in a number of cities. It will probably occur again, as will many other mishaps, electrical and other, serious or trivial, so long as the city having the largest electrical system in the world, confides so difficult and complicated a task as the devising, construction and regulation of its electrical conduits to men so conspicuously and absurdly incompetent as the machine politician, the theatre agent and the forward young attorney who constitute just three-fourths of the Board of Electrical Control. Neither its *ex-officio* member, the present energetic mayor, nor its capable electrical expert, Dr. Wheeler, can make such a board anything else than an object of alternate disgust and amusement.

ON the 29th of March, the Western Union Telegraph Co. attacked the Board of Electrical Control, through an order obtained from Judge Wallace, of the U. S. Circuit Court, temporarily enjoining the mayor and the board from directing the Commissioner of Public Works to remove poles and wires of that company from the streets. An order to show cause why the injunction should not be made permanent was made returnable in the Circuit Court April 3. The counsel of the Western Union company supported its application to the Court by alleging its right, acquired from the United States in 1867, to construct and maintain telegraph lines "over and along any of the military roads and post roads of the United States," under which designation the streets and avenues of this city are claimed to be included. It is further averred by the telegraph company that experience has shown that conductors placed in both their own and the public conduits are soon destroyed by heat and gas. Furthermore, it is charged in the complaint that the original Board of Electrical Control (Subway Commission) exceeded its duties by organizing a company to construct and maintain subways in the city streets, and in striving to compel the users of electrical conductors to rent spaces in those subways. The result of this proceeding will deeply interest the electric lighting companies, whose relations with the Board of Electrical Control are so accurately presented in the extract from *Texas Siftings* printed in another column.

ONCE more we repeat that the idea of street illumination by means of incandescent lamps is a fallacious and mistaken one.—*Electrical Review* (London).

Do not be too positive, neighbor. American experience, as we have been told more than enough times, is no criterion for England. Nevertheless it is a fact, that year by year, the use of the incandescent lamp for street illumination has gained in popular appreciation, and at least three of our leading companies, the Edison, the Thomson-Houston and the Westinghouse, are engaged in erecting street lighting plants with highly gratifying results. But note the fact that we always use 25 to 30 candle lamps, and not 10 or 16 candles; which makes all the difference in the world. The smaller candle-power does not give enough apparent illumination, and inferentially increases the cost of the plant by necessitating lamps at too short intervals. On the other hand, a higher candle-power than 30 implies greater intervals and a less satisfactory average distribution of light. One of the street plants of the Westinghouse company supplies 2,000 lamps, scattered through a district 12 miles long, from a single plant. The advantage of the incandescent system is more strikingly manifested on curved or heavily shaded streets. It looks to us, as if the idea of incandescent street illumination, instead of being a "mistaken one," is fast becoming recognized as a very sound and satisfactory one, except possibly for large open squares, and other exceptional places of like character.

IN contradicting the statement printed in the New York *World*, March 21, of the probable failure of the Villard scheme for consolidating the several Edison companies and bringing additional capital from Germany into the business, "a conspicuous friend of the Edison companies" is reported in the *Tribune* of March 22, to have said:—

There is no foundation for the printed statement, and certainly none for the conclusion that the negotiations have been broken off in consequence of the Canadian decision. * * * * There can be no monopoly of electric power; and for the benefit of the Westinghouse company, I will say that Mr. Edison has taken out no new patents lately, because he is treating the question of electric lighting as a mere business matter. The company that can furnish light at the lowest cost will be sure to get the business. The patent rights do not figure in the case at all. There is enough room in this country for more than two companies, and the greatest difficulty in both this country and Europe is to secure competent electricians. The expansion of the system is hampered by this lack.

For whose benefit soever made, this declaration is in refreshing contrast to many statements heretofore published

in behalf of the Edison company. It is a new sensation to be told that "the patent rights do not figure in the case at all." The statement is, we think, rather too sweeping, and hardly does justice to the position of the Edison company; although it is, perhaps, not so far wide of the mark as the immoderate claims formerly put forth.

We have received from the United Electrical Engineering Co., Limited, Westminster, England, an announcement of the undertaking by that company of the exploitation of the Jablochkoff patent of 1877 as covering electrical distribution by means of transformers. The communication states that the company has "concluded arrangements with the Leading Electric Lighting Companies involving both the recognition and support of the Patent." The following paragraph begins the announcement :—

It will not be a surprise to those who are familiar with the chronology of publications bearing on electrical distribution by means of transformers, and the terms of the judgment in favor of Messrs. Ferranti at the recent trial, that Jablochkoff's patent of 1877 is now recognized as covering the system.

It is not too much to say that it *will* be a surprise to a good many fairly familiar with the chronology of the subject if this movement result in the establishment of a monopoly in England of distribution by means of transformers.

Members of the electrical profession who depend upon the columns of our esteemed contemporary, the *Electrical Review*, for information and guidance upon points of patent law and practice ought to insist that its legal adviser be no longer permitted to formulate and indite his opinions at unseemly hours or after an evening at the Electric Club.

Immediately after the promulgation of the decision of the Supreme Court in the now celebrated Bate case, the following extraordinary tidings were spread abroad by him :—

An important patent decision extending the life of foreign patents to the extreme limit of time for which one can be granted, is published on another page.

Precisely how the life of a foreign patent is capable under any circumstances of being extended by a decision of the United States Supreme Court, we do not know. It has usually been supposed that foreign countries were out of its jurisdiction. In its next issue, after our contemporary's legal luminary had found time to study the opinion more carefully, it was announced that

The decision settled one point emphatically, and that is, that the life of an American patent first taken out in a foreign country, does not expire until *the extreme limit of time for which an extension of patent may be secured* in a foreign country.

The precise language in which the Supreme Court "settled" this point so "emphatically" is unfortunately not indicated, and so far as we are aware, nobody except our contemporary's solicitor has ever been able to find it; in fact the general impression among members of the bar has apparently been that the effect of the decision was about as nearly the reverse of the above statement as it well could be.

From a subsequent issue of the same journal we derive valuable information in respect to a decision on "one of the Edison lamp patents in Canada," and are informed that

This is, of course, not final, and like the decisions of our own Commissioner, is appealable.

It is hardly necessary to point out that the opinion thus declared by our contemporary overrules, reverses and inferentially pronounces unconstitutional the thirty-seventh section of the Canadian Patent Act, which provides that "if any dispute arises as to whether a patent has or has not become null and void under the provisions of this section, such dispute shall be decided by the Minister or the Deputy of the Minister of Agriculture, whose decision in the matter *shall be final.*"

Fortunately for the readers of our contemporary, its decisions in these matters cannot be regarded as "final."

Both parties to the storage battery suit just terminated appear to be well satisfied with the result. The Electrical Accumulator Co. announces that its Faure patent is sustained, whilst the Julien Electric Co. informs the public that it does not employ the process to which Judge Coxe limits the Faure claim, and does not desire to employ it.

OBSERVATIONS.

Judging from a recent article in the March number of *Electric Power*, that journal has become a convert to the "*motorneer*" idea.

Not that E. P. likes it, but because no other distinctive word is offered as a term for the man who starts and stops an electromotor. But is a distinctive term required? And is it necessary to have a word ending with the syllable "*neer*"? How about the man who starts and stops a water motor?

The observer likes this word less than many other really unnecessary words that have crept into use, for this reason among others, that it implies a species of monopoly in motor-ship to the electromotor; "Telegram," though perhaps not etymologically correct, is an expressive and not inelegant word, and there is good reason for its retention.

If this new word be adopted, it will be necessary to rob Peter to pay Paul; since, for euphony, the *n* from engineer has to be lugged in. Let others if they so desire become "*motorneers*"; the observer prefers, so far as this word is concerned, to remain a mutineer; *anglice*, a kicker.

. . .

Copper is coming down. Nay, it has come down. Since the downfall of our friends, Messrs. Secretan, *et al*, long prophesied, has come, we may expect shortly a reasonable decrease in the price of copper, and a proportionate increase in the amount used; especially in telegraphy and telephony.

The final crash of the syndicate was signified to the Boston copper mine stockholders, by the action of the Faneuil Hall Grasshopper, a huge insect of copper, having viscera composed of a large number of coins of several nations, which evacuated its perch on Monday, March 18th, while the citizens below, were celebrating the evacuation of Boston by the English. The grasshopper, however, is to be stitched up and promptly restored to its elevated post of observation, and in this instance, probably, will not serve as a portent, since it is heavy odds that the price of the rest of the world's supply of copper will be cheaper before it is dearer.

.. So rapid has been the development of the electric industry, few have been able to keep trace of its achievements, and fewer still have sounded its possibilities for the purpose of giving direction to its growth.—*A. R. Foote.*

.... As the freedom of the spirit is greater than the freedom of the body, so is the distribution of electric power freer than that of all other forms of force. It is their spirit.—*A. R. Foote.*

ARTICLES.

THE EFFICIENCY OF METHODS OF ARTIFICIAL ILLUMINATION.[1]

BY EDWARD L. NICHOLS.

(Professor of Physics in Cornell University.)

OF human industries of the present day none perhaps, save those which have to do with providing the race with food, clothing, shelter and fuel, is more important to the cause of material welfare than that which deals with the production of artificial light, and he who seeks a means of measuring the material civilization reached by a nation might find an excellent criterion in the progress which it exhibits in the art of illumination.

The problem of comparing the various methods of artificial lighting which are in vogue at the present day is one of great interest, whether we view it from the commercial standpoint, taking the cost of production as our controlling factor, or from the broader basis of relative usefulness, cost being relegated to a secondary position, or, finally, from the purely scientific point of view. From whichever side we approach this question, we are led inevitably to the consideration of certain elements which are alike of scientific, utilitarian and commercial importance.

At first sight the attempt to determine the relative value of two sources of light would seem to be a simple matter. The number of factors, however, which enter into such a determination is surprisingly large, and many of them are of a character which makes it difficult to give them definite and complete expression. Of these the greater part are indeed commonly left out of account altogether, for the sake of simplicity, and we content ourselves with an antiquated and totally insufficient measure of our sources of illumination, which we call candle-power. It is to these other elements which enter into the question of the character of artificial light—such, for instance, as have to do with its *quality*—but which are, as a rule, quite lost sight of, to which I would ask your attention this evening, together with a discussion of those which are commonly made use of in photometry. If, in so doing, I am led to speak of methods which belong to the realm of pure science, I trust that you will agree with me in thinking that the results are not unimportant even to those whose interest in the problem of the production of artificial light is purely utilitarian.

In the important question of the efficiency of a light-producing machine or process, the practice of to-day is very far from having reached that degree of exactness of expression which we demand in other cases of the transformation of energy. In electric lighting the energy expended is readily determined in absolute measure, or in that excellent practical unit, the *Watt*. In lieu of any attempt to express the useful energy obtained, however, we still content ourselves in practice with that most unscientific unit, the candle-power, based upon a source of illumination which is particularly subject to fluctuations of intensity and color. Even as used in the Bunsen photometer the shortcomings of the standard candle are sufficiently apparent; but no one who has not attempted to study it by methods which make it possible to detect changes of color as well as of brightness, can fully appreciate its fickleness.

Such as it is, we do not, moreover, make the best of the standard candle as a basis of comparison of artificial lights. We speak of a 16-candle incandescent lamp, for instance, meaning oftentimes "mean spherical candle-power" and then we compare it with a petroleum or gas flame, measured in the horizontal plane only, much to the disadvantage of the electric lamp. The study of the distribution of intensities in accordance with the very complete system devised for that purpose by the Franklin Institute Committee in 1884, affords an invaluable means of comparing the performance of various types of incandescent lamps; but the adoption of "mean spherical candle-power" as obtained by that method, is, to say the least, misleading when it comes to the comparison of electric lamps with candles, oil or gas. It is to be hoped that when the present confusion of methods of measuring candle-power now existing in the electric lighting establishments in this country is supplanted by a recognized system, the fairer standard already established by law in England, viz., mean horizontal candle-power, may be adopted. It is, however, in the comparison of arc and glow lamps that the latter are put at the greatest disadvantage. Here we pit the incandescent lamp, using mean spherical candle-power as our basis, against candle-power measured at the angle at which the arc light sends out the greater part of its rays. Indeed, in too many cases, it is not with the actual intensity even in this most favorable position with which we have to do, but with an estimated or "nominal" candle-power which the arc, in matter of fact, never approaches.

The electric arc stands quite alone, for the purposes to which it is adapted, and need fear no rivals. It does not need to be estimated upon any fictitious basis, and the continuance of the pernicious practice of ascribing to it powers of illumination which it does not possess must, in a great measure, be charged to the account of the standard candle; for with the best intentions in the world, the comparison of sources of light differing so widely in color as the candle and the electric arc, is nothing more than a rude approximation, leading by its very inaccuracy to the temptation of the grossest exaggeration.

There are, fortunately, better methods of estimating the efficiency of a lamp than that which is based upon candle-power.

We may, for instance, determine the ratio of the energy of the light-giving radiation to that of the total radiation of the source of illumination. The efficiency of the incandescent lamp, according to this definition, has been recently determined by Mr. Ernest Merritt,[2] of the Physical Laboratory of Cornell University. Mr. Merritt followed two independent methods of investigation. In his first experiments the lamp was placed in a calorimeter constructed entirely of glass, figure 1, through which a constant flow of

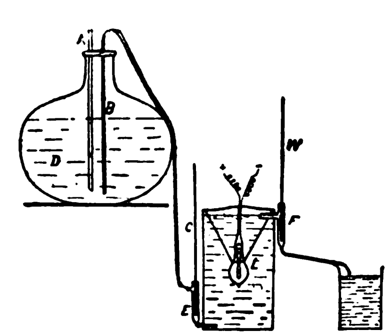


FIG. 1.

water was maintained. The temperature of the water upon entering and upon leaving the calorimeter was measured by means of the thermometers E and F. From this difference of temperature and the amount of water discharged in a given time, the heat absorbed by the calorimeter was calculated; proper corrections for loss of heat by radiations, etc., being applied. Now the water with which the calorimeter was filled is nearly transparent to the light-giving radiations from the lamp, and almost entirely opaque to the longer wave lengths which constitute the so-called heat spectrum. To have assumed it to be entirely so, would, however, have involved very considerable errors, and the diathermancy of the calorimeter on the one hand and its power of absorbing the luminous wave-lengths on the other, were accordingly carefully determined by methods

1. A paper read before the American Institute of Electrical Engineers, March 12, 1889.

2. Ernest Merritt, *American Journal of Science*, vol. 37, p. 167.

long since elaborated and made use of by Melloni and by his distinguished English follower, Professor Tyndall. By applying these and other necessary corrections, we are able to calculate very accurately in watts, the non-luminous radiation from the lamp. The ratio of the total radiation, obtained either by submerging the lamp in a metallic calorimeter or by direct computation from the current and electromotive force gives the actual efficiency of the lamp considered as a light-making machine. The result is not a gratifying one, when we compare this process with most others in which energy is transformed. The efficiency of the best types of incandescent lamps, previous to the introduction of the recent three watts per candle lamps now in successful operation, which would doubtless make a somewhat better showing, was found to be rather under than over five per cent. at normal candle-power; the values ranging from 0.5 per cent. to 6.5 per cent. The last-named value for the efficiency was attained only at a temperature incompatible with any considerable length of life. The results obtained in this investigation are shown in table i.[3] and in the accompanying diagram, figure 3.

TABLE I.[4]

Lamp A. Edison.

E. M. F.	W	C. P.	L	$\frac{L}{W}$	$\frac{L}{C.P.}$
74.2	34.6	0.9	0.18	0.005	0.59
91.6	56.2	4.8	0.68	.012	0.14
97.3	64.6	7.3	1.13	.017	0.15
100.3	69.3	8.9	1.62	.023	0.18
107.6	81.6	14.6	2.97	.036	0.20
109.3	84.4	16.3	4.57	.054	0.28
124.1	115.4	38.2	7.46	.065	0.19

In this table W is the total energy, in watts; L the energy of the light, also measured in watts; and C. P. the candle-power.

The second method pursued by Mr. Merritt was intended rather as a check upon the results already obtained than in the expectation of gaining further data. The rays of the lamp were allowed to fall upon the face of a delicate thermopile placed at a distance of about 60 cm. The thermopile was in circuit with a low resistance galvanometer of the well known "tripod pattern" of Sir William Thomson. The deflection of the galvanometer was taken as a measure of the total radiation, luminous and non-luminous, which fell upon the face of the pile. A cell containing a solution of alum was now interposed, and the reduction in the galvanometer noted. The arrangement of this apparatus is shown in figure 2.

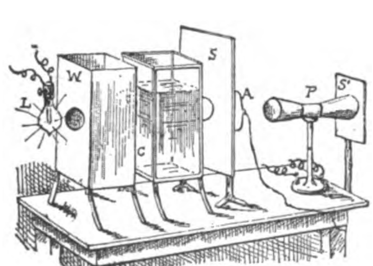


FIG. 2.

An aqueous solution of alum fulfills much more nearly the desired condition of complete opacity to "dark heat" and complete transparency to the rays of the visible spectrum than any other substance, but a certain small percentage of the longer wave lengths will pass through such a bath, and a considerably larger percentage of light-giving rays will be cut off by it. The proper corrections are, however, easily determinable, and when in this case they had been determined and applied, the ratio of total to luminous radiation was found to be in gratifying agreement with the efficiency obtained by the calorimetric method already described. See table ii.

TABLE II.

Lamp B.

An Edison 16 c. p. lamp. Resistance — 249 ohms.

E. M. F.	W.	C. P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
63.0	25.4	0.3	0.42	0.016	1.61
74.6	37.8	1.0	0.77	.021	0.79
85.4	52.5	2.5	1.96	.037	0.78
99.0	72.2	6.3	4.30	.059	0.68
116.0	102.0	15.2	7.38	.072	0.49

Lamp C.

Weston 16 c. p. Cold resistance — 402 ohms.

E. M. F.	W.	C. P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
72.0	21.6	0.4	0.46	0.021	1.27
87.4	33.5	1.5	1.10	.033	0.76
102.0	47.8	4.4	2.09	.044	0.48
117.0	66.1	10.7	3.19	.048	0.30

Lamp D.

Weston 16 c. p., 70 volt. Resistance — 152 ohms.

E. M. F.	W.	C. P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
43.0	25.8	0.5	0.53	0.021	1.06
50.7	36.0	1.6	0.97	.027	0.62
60.5	52.0	5.2	2.03	.039	0.39
67.5	65.5	11.0	3.95	.060	0.36

Lamp E.

Bernstein 8 c. p. Resistance = 11.3 ohms.

E. M. F.	W.	C. P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
12.2	25.2	0.2	0.20	0.008	1.00
13.4	30.8	0.5	0.41	.013	0.84
15.0	40.4	1.3	0.75	.018	0.57
16.4	53.2	4.1	2.03	.038	0.50

It is interesting to compare these results with some obtained by still another method. Captain Abney and Colonel Festing in the Proceedings of the Royal Society have described a series of elaborate studies of the radiation of the incandescent lamp. The portion of their very important investigation which has a bearing upon the efficiency, deals with the exploration of the spectrum of the lamp, under various degrees of incandescence, by means of an exceedingly sensitive thermopile. The energy of the visible spectrum of most sources of light is so minute that it has generally been deemed impracticable to measure it in this way. Captain Abney and his co-worker have, nevertheless, secured measurements covering not only the extensive regions of the so-called heat spectrum lying inside the red, but also the shorter wave lengths which constitute the

3. Dr. Blattner in an Inaugural Dissertation, published at the University of Zürich, gives similar values for the efficiency of the incandescent lamp. He finds, as the result of extended measurements with the glass calorimeter, that * * "at the normal temperature of incandescence, where the intensity lies in the neighborhood of 16 candles, the efficiency does not rise above five per cent. to six per cent."—Emil Blattner; *Der Optische Nutzeffect der Glühlampen*, Frauenfeld, 1886.

4. Tables i. and ii., and figures 1 and 2, are taken from Mr. Merritt's paper, already referred to.

visible spectrum. Their results are shown graphically in figure 3.

One of the British Electric Co.'s lamps was subjected to measurement in six different states of incandescence, corresponding to 33.6, 60.2, 93.8, 116.4, 130.8 and 150.5 watts respectively. The curves show the intensity of each wave length of the spectrum. When the above amounts of energy were expended in the filament, and the total area inclosed by each curve affords a relative measure of the total radiation of the lamps in the state of incandescence in

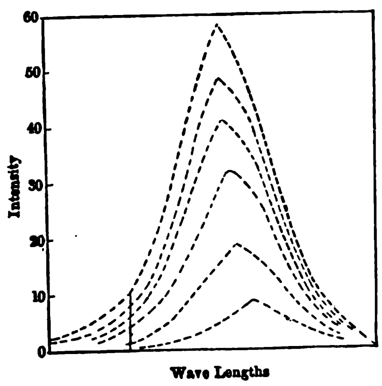


FIG. 3.

question. I have added to this diagram, of which, in other respects, figure 3 is a faithful reproduction, the vertical line lying between scale divisions 5 and 6 of their scale. This line marks the boundary between the visible and invisible spectrum. The entire area to the right of that line represents the energy wasted in the lamp; the much smaller area to the left comprises the light-giving rays. The ratio of the entire area of each curve to that portion lying within the boundaries of the visible spectrum gives us the efficiency of the lamp for the state of incandescence produced by the expenditure of the number of watts for which the curve is drawn. This ratio increases from a very small value with the brightness of the lamp.

I have made approximate integrations of the areas embraced by the curves for 150.5 and 130.8 watts, respectively, for the purpose of comparing the efficiency thus calculated with the results obtained by Mr. Merritt. The ratios are :—

Watts.	Efficiency.
150.5	5.55 per cent.
130.8	5.15 "

The corresponding values for lower states of incandescence are all smaller than the above.

It will be seen that these results are in complete agreement with those obtained with the glass calorimeter and by the method of Melloni. We have, indeed, reason to feel that our knowledge of the absolute efficiency of the incandescent lamp, in so far as it can be expressed by the ratio of luminous to total radiation is well grounded, and that we are in position to determine the light-giving efficiency of any type of glow lamp in any condition of incandescence with the same certainty and exactness which is attainable in the measurement of other machines for the transformation of energy.

The average net efficiency of the incandescent lamps of to-day, for we may leave untouched for the present the efficiency of the processes by which the latent energy of fuel from which the current is generated has been converted into electrical energy, is rather below, than above five per cent.; and since the ratio of total radiation to light-giving radiation increases but slowly as the temperature of the radiating body rises, the efficiency is not likely to be increased in any very marked degree until we shall have learned how to suppress altogether these long wave lengths which yield us dark heat, and are able to limit the vibrations of our source of light to that brief octave which comprises the wave lengths to which alone the human retina responds.

Whether this great step is to be made by robbing the glow-worm and fire-fly of their secret, as has been suggested in a recent address by the director of the Sibley College of Mechanical Engineering,[5] or by development along the lines sketched the other evening by Professor Brackett at the meeting of the Electric Club, or by the application of some principle as yet unconceived, we know not. Meantime, we have in the methods of artificial lighting of to-day abundant material for study and investigation.

The investigation of the efficiency of the arc light by the methods under consideration, is a much more difficult matter than the same determination in the case of the incandescent lamp. The radiating surface of the latter is very nearly of the same temperature throughout, and the ratio of total radiation to luminous radiation, obtained for the bundle of rays sent out in a single direction, gives us at once the measure of the efficiency. In the arc we have, however, a light-giving area of great brilliancy in the immediate neighborhood of the arc, and the temperature of the carbons falls with great rapidity from the maximum at the point and crater to regions which are at a red heat.

The entire light-giving area is included between the line surrounding the positive carbon, which is at red heat, and the corresponding line upon the negative carbon. Between these two lines we pass rapidly through regions, the light from which varies with the degree of incandescence by insensible gradations from that which a red hot surface is capable of emitting to that coming from carbon at the highest temperature which that substance can be made to assume. Now, the curve of distribution of candle-power taken in a vertical plane is, as we all know, a very peculiar one, and if we place our thermopile with alum cell interposed to measure the energy of the light-giving rays, the amount of radiation received upon the face of the pile will greatly depend upon the position in which the apparatus is set up. At an angle of 45 degrees, or 50 degrees below the horizontal plane, for instance, the amount indicated will be five or six times greater than in the horizontal plane. Now, the surface of total radiation is much larger than that from which the light-giving rays emanate. It includes, in addition to the incandescent surfaces near the arc, all those portions of the carbons which are heated, either by conduction or by the current.

The amount of heat radiated from regions which are below the red heat is very considerable, and forms an important factor in the determination of the efficiency. Were the distribution of total radiation in the vertical plane identical with that of the light-giving rays, the measurement of their ratio with the axis of the thermopile in any plane which passes through the arc, would give us the efficiency of the lamp; but the curve of distribution of total radiation is not the same as that of candle-power, and the ratio in question is a function of the plane which the axis of the pile makes with the horizon. It becomes necessary, therefore, to make an exploration of the entire zone through which the lamp sends out rays, determining the ratio of total to luminous radiation for each angle, and then to integrate the results. Such an investigation is now in progress under my direction, and Mr. H. Nakano, who is carrying on the experiments, has reached some exceedingly interesting results. The research will soon be ready for publication in its complete form, and it will

5. "The second of these greatest of inventors is he who will teach us the source of the beautiful soft-beaming light of the fire-fly and the glow-worm, and will show us how to produce this singular illuminant, and to apply it with success practically and commercially. This wonderful light, free from heat and from consequent loss of energy, is nature's substitute for the crude and extravagantly wasteful lights of which we have, through so many years, been foolishly boasting. The dynamo-electrical engineer has nearly solved this problem. Let us hope that it may be soon fully solved, and by one of those among our own colleagues who are now so earnestly working in this field, and that we may all live to see him steal the glow-worm's light, and to see the approaching days of Vril predicted so long ago by Lord Lytton."—ROBERT H. THURSTON—*Transactions of the American Society of Mechanical Engineers*, 1881, p. 22.

afford us much more definite data concerning the radiations of the electric arc than we now possess. It will not be out of place even now to say a word concerning the method which is being employed, and the general character of the results already obtained.

The first measurements were made by the second method employed by Mr. Merritt, the thermopile in the horizontal plane. The lamp subjected to measurement was of the long-arc type, with 9 amperes of current and 45 volts. The efficiency in this plane was found to be surprisingly small. It was found, moreover, to vary in marked degree with the diameter of the carbons used, increasing as the diameter decreased to the point at which the carbons were rendered hot by the current, when, as might be expected, it fell off again.

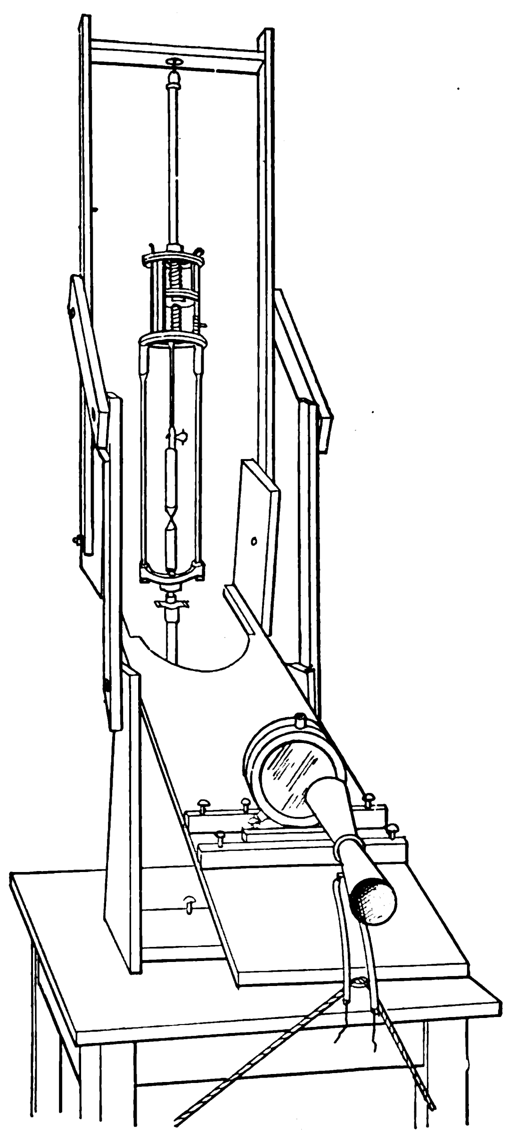


FIG. 4.

The lamp was then mounted in a frame which also carried the thermopile and alum bath, and which was so constructed that measurements could be made at any desired angle. All necessary changes of angle could be made without varying the distance from the arc to the face of the pile, or the relation of the alum bath to the latter. By means of this apparatus, which is shown in figure 4, it has been found possible to determine the ratio of total to luminous radiation throughout the zone of radiation of the lamp, and to plot the curve of distribution of each.

Without entering into the details of an incompleted research, I may indicate the general character of the results by means of a diagram. The curves shown in figures 5 and 6 are those relating to a "long-arc" lamp with carbons .45 inch in diameter. They represent respectively the distribution of luminous and total radiation emanating from the lamp. The radii show the positions for which

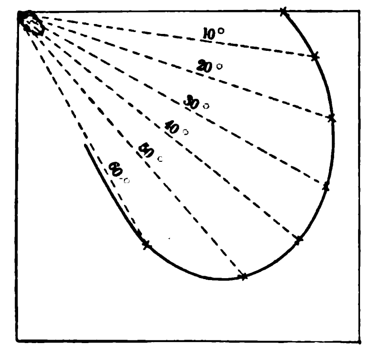


FIG. 5.

measurements were taken; distances measured along these lines from the origin to each curve give the relative intensities of light-giving and total heat energy in each position.

The curve of luminous radiation corresponds in form with that of candle-power. The distribution of total

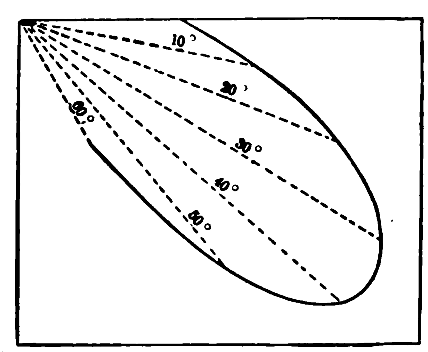


FIG. 6.

radiation, however, differs widely from these, and the ratio, $\frac{\text{luminous energy}}{\text{total energy}}$, is a function of the angle which the line of measurement makes with the horizontal plane. The values of the efficiency in the case in question for the various angles at which measurements were made, are given in table iii. They form the basis for the curve in figure 6, which is the diagram of efficiencies of the arc light under the conditions of operation already stated.

TABLE III.

Efficiency of an arc lamp; after measurements by Mr. H. Nakano.

Angle.	Efficiency. $= \frac{\text{Luminous radiation.}}{\text{Total radiation.}}$
0°	.0548
10°	.0901
20°	.1228
30°	.1506
40°	.1552
50°	.1059
60°	.0676
63°	.0492

The integration of these values gives as the mean efficiency of the arc lamp in question, .104, or 10.4 per cent.

The ratio of the radii of two semicircles, the areas of which equal the areas inclosed by the curves of luminous and total radiation, gives us a measure of the "mean spherical" efficiency of the lamp. This ratio in the case of the lamp to which these curves refer is very much smaller than the generally accepted values of the efficiency

of arc lamps, expressed in terms of the candle-power per watt, would lead us to expect. The intensity of the arc is, however, seldom expressed in mean spherical candles, and there are few data relating to the candle-power of this source of light upon which to found satisfactory estimates. On the one hand we find it stated, doubtless correctly, that the mean light-producing efficiency of the eleven dynamos, tested at the International Health Exhibition, held in London in 1884, was 1,440 candles per horse-power,[6] while the glow lamps only yielded 175 candles, and it is with estimates similar to the above with which we have generally to satisfy ourselves in comparing arc and incandescent systems of illumination.

For the purpose of deciding whether the results of Nakano's method of determining the ratio of luminous to total radiation are compatible with our other sources of knowledge concerning the arc light we must make use of mean spherical candle-power as our basis of comparison.

Very careful measurements of the mean spherical candle-power of two arc lamps of representative and successful commercial types were made in the physical laboratory of Cornell University,[7] following the method of the Franklin Institute Committee. Both of these lamps were rated at 2,000 c. p. They were maintained by dynamos of the types for which they had been especially designed, working under normal conditions. One of the lamps gave a mean spherical candle-power of 295, when working in series with nine other lamps of the same construction. When placed in circuit alone, the candle-power rose to 348. The energy expended in the lamp in each case was 550 watts, and the efficiency accordingly 1.8 watts and 1.6 watts per candle.

The other lamp was found to reach 609 mean spherical candles at the cost of 601 watts. An inspection of the result obtained by the Franklin Institute Committee would lead us to regard these as extreme values, between which the performance of almost all arc light would lie, as a rule, nearer the lower than the upper of these limits. The efficiency of arc lights, then, expressed in mean spherical candle-power per watt is frequently as low as 1.5 times that of the incandescent lamp, and, rarely, three times as high. Now the mean efficiency of the arc lamp under discussion *i.e.*, the ratio, $\frac{\text{luminous radiation}}{\text{total radiation}}$, according to the measurements of Mr. Nakano, is almost exactly 10 per cent. The efficiency of incandescent lamps, defined in the same way, according to Mr. Merritt, may, as we have seen, be taken at about 5 per cent. The ratio is 2:1 in favor of the arc lamp, which lies within the limits determined by comparison of candle-power and watts.

Small as these values for the efficiency of the electric light are, they show marked improvement over the efficiency determined in a similar manner for sources of illumination which depend upon the incandescence of carbon by direct combustion. More than a quarter of a century ago, Julius Thomsen[8] presented before a gathering of Swedish men of science, the results of an investigation of the energy consumed in the sperm candle, and in various oil and gas flames. His memoir bore the suggestive title of the Mechanical Equivalent of Light, and is one of the earliest contributions to our knowledge of the energy of luminous radiation.

The instruments employed in Thomsen's experiments were the thermopile and galvanometer, the indications of which were reduced to absolute measure by determination of the deflection produced by the radiation from a glass globe filled with hot water. The total loss of heat by radiation which this globe suffered was calculated from its rate of cooling, using Dulong and Petit's law. The water equivalent of the globe was 1,351 grains; its total loss of heat per minute at 50 degrees C. was 250 calories; its loss of heat by radiation at the above temperature, when the air of the room was at 17 degrees, was 102 calories per minute. Under these conditions the influence of the globe of water upon the thermopile placed at a given distance was observed. A luminous body having been substituted for the globe, its influence on the pile was likewise noted, and its total radiation in calories calculated by comparison of the deflections produced in the two cases.

For a sperm candle burning 8.2 grains per hour, the total radiation estimated by this method was 210 calories per minute. Other flames gave out quantities of heat nearly in proportion to their candle-power, as will be seen by inspection of table iv.

TABLE IV.

Calories per candle-power radiated by various flames, according to Julius Thomsen.

Source of illumination.	Candle-power.	Calories per candle.
Sperm candle..........	1.	210
Gas flame.............	1.2	201
Gas flame.............	7.7	199
Moderator lamp........	8.6	199

The luminous energy was obtained by a method similar to that pursued by Merritt in the experiments already described. A bath containing a layer of water 20 cm. in thickness was interposed between the lamp and the thermopile and the indications of the galvanometer noted. The results were based upon the assumption that the cell absorbed 13 per cent. of the light and all of the dark rays. This estimate is doubtless faulty, and may involve a reduction of several per cent. from the values given by Thomsen. His results, uncorrected, are as follows :—

TABLE V.

Energy of luminous radiation of various flames in calories, according to Julius Thomsen.

Source.	Candle-power.	Luminous energy per c. p.
Candles..................	1.	4.4 calories.
Moderator lamp...........	6.25	3.9 calories.
Moderator lamp...........	8.6	4.1 calories.
Gas......................	7.7	4.2 calories.
Gas......................	1.2	3.7 calories.

The energy of the light-giving rays per candle-power of light produced is then, according to Thomsen, very nearly the same for the flames of the candle, oil lamp and gas burner. This conclusion has been abundantly confirmed by spectrophotometric observations of the quality of the light which they emit. It appears, moreover, from these observations, of which I shall have occasion to speak at length presently, that the temperature of the incandescent particles in such flames agrees very closely indeed with that of an incandescent lamp, consuming 5 watts at 16 c. p, being, as a rule, lower, rather than higher, than the latter; and the calculation of the energy of such a lamp in calories per minute, making use of the data furnished us by the investigation of Abney and Festing, or of Merritt, affords most satisfactory evidence of the accuracy of Thomsen's results. Let us take for example the case of an incandescent lamp in which 5 watts per candle-power are expended, and in which the ratio

$$\frac{\text{Luminous radiation}}{\text{Total radiation}} = .05.$$

The energy converted into light in such a lamp is .25 watt. Now,

$$1 \text{ gramme-calorie} = 4.2 \times 10^7 \text{ ergs.}$$

$$1 \text{ watt} = 10^7 \text{ ergs} = \frac{1}{4.2} \text{ gramme-calories per second.}$$

$$.25 \text{ watt} = \frac{.25 \times 60}{4.2} \text{ gramme-calories per minute,}$$

and the heat equivalent of the luminous energy is 3.6 gramme-calories per minute.

6. Julius Maier, Arc and Glow Lamps, p. 52.

7. *The Photometry of Arc Lights*. Thesis by Benjamin W. Snow, 1885. MS. in the Library of Cornell University.

8. Julius Thomsen: Das Mechanische Æquivalent des Lichtes; *Poggendorff's Annalen, Bd.* 125, p. 348.

This value is somewhat smaller than those given by Thomsen in the preceding table, but proper corrections for the diathermancy of the water bath used in his experiments and for the difference in standards of candle-power —the light given by his sperm candle being slightly in excess of the legal standard of the present day—will bring the two into excellent agreement.

The entire energy developed by the chemical reactions occurring in these flames per candle-power of light produced were, however, about 1,400 calories in the case of candle and oil lamps, and 4,100 calories in the case of gas, so that the gross efficiency would be respectively 0.3 per cent., and 0.1 per cent. The average ratio of total radiation reaching the thermopile to luminous radiation is about .2 per cent., but this ratio cannot be considered in the same light as that obtained in the case of the incandescent lamp, since a gas or oil flame is in reality a column of heated vapor containing particles of unconsumed carbon, which reaches far above the luminous region, sending out dark rays from its upper and cooler portions, which do not reach the face of the thermopile at all. The relation which the total radiation of this heated column bears to the heat dissipated by convection cannot be determined, and the determination of total radiation from the light-giving portions alone is of little value. It is only in the matter of gross efficiency, therefore, that we can institute a comparison between electric lamps and the older methods of illumination, and the gross efficiency of the former depends upon the efficiency of production of electric current. Under conditions, such that 10 per cent. of the total energy of the fuel consumed is converted into electricity—conditions, which are, I believe, rarely attained by our present methods—the gross efficiency of an incandescent lamp, of which the net efficiency, determined by the methods which I have already described, is 5 per cent., would be 0.5 per cent ; a value which is five times greater than that of a lamp burning the kind of gas used by Thomsen, and which stands in the ratio of 5 : 3 (or, probably, rather more than that) to the gross efficiency of an oil flame. These flames must, of necessity, vary very widely with the quality of the fuel consumed, and with the condition under which combustion is maintained.

If we apply a similar method of computation to the values given by Mr. Preece in his recent address at the Bath meeting of the British Association for the Advancement of Science,[9] assuming that the conditions under which each illuminant is consumed are such that the temperature of the incandescent carbon equals that which is maintained in the filament of an incandescent lamp at 5 watts per candle, with a net efficiency, as before, of 5 per cent., a set of conditions which can be attained in practice only in the most perfectly constructed oil and gas lamps, and which are fulfilled in many of the best of our incandescent lamps of to-day, we obtain the following results :—

TABLE VI.

Gross efficiency of various illuminants deduced from the values given by Preece. The heat equivalent of a candle is assumed to be 3.6 gramme calories per minute.

Illuminant.	Watts per candle. (Preece.)	Gramme-calories per minute per candle.	Luminous radiation. / Total radiation = gross efficiency.
Tallow	124	1770.	.00203
Wax	94	1340.	.00268
Sperm	86	1230.	.00293
Mineral oil	80	1143.	.00315
Vegetable oil..	57	815.	.00442
Coal gas.	68	971.	.00317
Cannel gas.....	48	685.	.00521

9. Preece. Address before Section A, meeting of the B. A. at Bath, 1888. Nature, vol. 38, p. 496.

In considering these values it should be borne in mind that coal-gas is a fuel which has been obtained by the previous expenditure of considerable energy. Were we to take as our basis the consumption of coal necessary to the production of a candle-power of light, instead of the heat of the combustion within the gas flame itself, the values for the efficiency of coal-gas as an illuminant would be very considerably reduced.

We have already seen that there are excellent experimental grounds for the statement that the gross efficiency of the incandescent lamp is about .005, and that of the arc lamp about .01, under the assumption of the waste of 90 per cent. of the total energy of the fuel in the various processes leading to the production of the current, and that the latter figures, small as they are, are considerably in excess of the gross efficiency of candles, oil or gas. We are in possession, moreover, of the means of expressing exactly the degree of superiority which the electric light possesses over those illuminants in the important matter of the heating effect upon the surrounding atmosphere. Gas and oil flames deliver in the neighborhood of 1,000 gramme-calories of heat per minute to the room for each candle-power, of 3.6 gramme-calories of luminous radiation. An incandescent lamp of 5 per cent. net efficiency delivers only 72 gramme-calories per candle-power.

The net efficiency of the incandescent lamp may be raised somewhat by increasing the temperature of the carbon filament, and, indeed, it has already been somewhat raised by the introduction of the new "3 watt" lamps. These lamps have been excluded from this discussion because we have as yet no complete data with reference to them, and because it seemed desirable, aside from that, to institute comparisons between sources of illumination in which the degree of incandescence was the same, and for all of which, consequently, candle-power had the same meaning.

When we raise the temperature of our source of light, however, we introduce changes, of which the methods thus far considered take no cognizance.

In increasing the degree of incandescence, the ratio of luminous energy to total energy of radiation is slowly increased, and at the same time the relative brightness of the various rays which constitute the visible spectrum changes. In a word, the *quality* of the light changes, and we are confronted by important variations which cannot be expressed in candle-power.

The investigation of these changes in composition, upon which color depends, involves the study of the visible spectrum of the source of light and the comparison of its intensity, wave length for wave length, with the spectrum of some properly chosen standard. The instrument necessary to this work is the spectro-photometer, by means of which the spectra of the two lights to be compared are brought together in the field of view, one above another, like wave lengths everywhere in the same vertical line. The measurements consist in bringing the two spectra to the same intensity in each of the regions selected for observation successively, and in determining the amount by which it is necessary in each case to reduce the intensity of the brighter. A variety of devices have been made use of for varying the brightness of the spectra, and the standards of comparison adopted by different observers have included the candle, the petroleum flame, the gas flame, and the incandescent lamp, maintained at a constant voltage. Thus W. H. Pickering[10] obtained the necessary range of intensities by placing the lamp under inspection upon a sliding carriage and varying its distance from the slit of the spectroscope. His standard of comparison was a gas flame. H. C. Vogel[11] used as his standard a petroleum flame. Crova,[12] who brought the intensities of the two spec-

10. W. H. Pickering, *Proceedings* of the American Academy of Arts and Sciences, vol. 15, 1880.

11. H. C. Vogel, *Berliner Monatsberichte*, 1880, p. 801.

12. A. Crova, *Comptes Rendus*, 87, 1878, p. 322.

tra to equality by means of a polarizing device, adopted the moderator lamp as a standard. Otto Schumann, in his study of the incandescent lamp, made use of a "benzine" candle. The intervention of a revolving disc with open and closed sectors and of wedges of smoked glass have also been applied to the regulation of the intensity, and the method of varying the width of the slit itself, a device due to Vierordt, has been found to give good results, where the range of intensities was inconsiderable.

The methods of presenting the results of this class of measurement have differed as widely as the methods of observation and the choice of standards; but it is possible wherever the data are properly given and the character of the standard is known, to reduce them all to a common basis of comparison. When thus reduced these measurements are found to agree in all essential particulars, and they afford us very definite knowledge of the character of the light emitted by the sources of illumination to which the spectro-photometer has been applied.

Figure 7 shows the form of the spectro-photometer recently used by Mr. W. S. Franklin and myself in an extended series of observations upon artificial sources of illumination and in the comparison of their spectra with that of daylight.

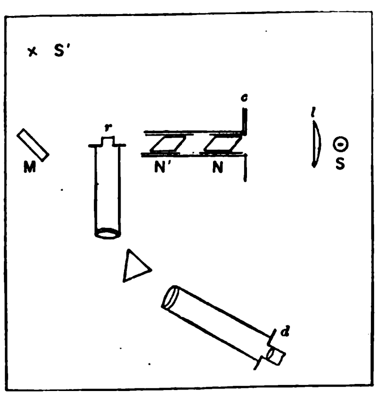


FIG. 7.

To the slit of a one prism spectroscope are attached a set of total reflection prisms, *r*, by means of which rays may be introduced into the upper and lower halves of the slit, these rays coming respectively from sources of illumination placed to the right and left-hand in a line at right angles to the axis of the collimator tube. The standard of illumination, which is an incandescent lamp S, maintained at 16 candles, is placed at the observer's right hand.

Its rays having been rendered parallel by means of a condensing lense, *l*, pass through a pair of Nicol's prisms, N and N', the first of which is free to revolve, and enters the upper half of the slit. The intensity of the spectrum of this lamp can be reduced at will by the rotation of the first Nicol, and its brightness is calculated from the angle between the flames of polarization of the two Nicols. To the left of the slit is mounted a block of magnesium carbonate, its face vertical and forming an angle of 45 degrees with the axis of collimation of the spectroscope. The rays of the source of light to be investigated, S', which is placed at a convenient distance, fall upon the magnesium carbonate, and it is such of the diffusely reflected rays from the latter as reach the total reflection prisms, and thus enter the lower half of the slit, which form the second spectrum. The object gained by the interposition of this white surface is an important one. All artificial light, except that from an incandescent lamp, emanate from glowing materials varying greatly in temperature, and the spectrum obtained directly from the source is always that due to some particular portion of the luminous body under investigation, to the exclusion of the remainder, and differs more or less in character from that of the source taken as a whole.

The spectrum of rays reflected from the face of the magnesium carbonate, however, contains in proper proportions the light from all portions of the source, and one of the chief sources of error to which spectrophotometric work is subject, is thus eliminated.

The investigations made with this instrument, which have been described in a paper read before the American Association,[13] included the measurement of candle flames, and of various petroleum and gas lamps, also of the lime light, the incandescent lamp under a wide range of conditions, of the electric arc and of daylight by clear and by clouded sky. The results obtained illustrate the precise character of those differences in composition to the bearing of which, upon the study of the efficiency of artificial illumination, I desire to call your attention.

In the first place it was found that the light of the candle, and of oil and gas flames, although subject to considerable fluctuations from variations of the condition under which combustion occurs, differ but slightly in quality from each other and from that of incandescent lamps maintained at normal candle-power. The incandescent material in all is carbon; and it is a significant fact that the average temperature of incandescence is nearly the same in all luminous flames, and that the highest temperature, until very recently at any rate, at which it has been found practicable to maintain the carbon filament of the glow-lamp, is very nearly that at which the same material exists under the most favorable conditions in oil and gas flames. Hence it is that the radiant energy per candle-power, as has been shown by Julius Thomsen, is nearly the same for all these flames.

Passing to other sources of illumination, such as the lime light and the electric arc, we find the entire portion of the spectrum lying beyond the yellow increasing more rapidly, regions of longer wave length than the yellow increasing less rapidly than the candle-power; the rate of increase

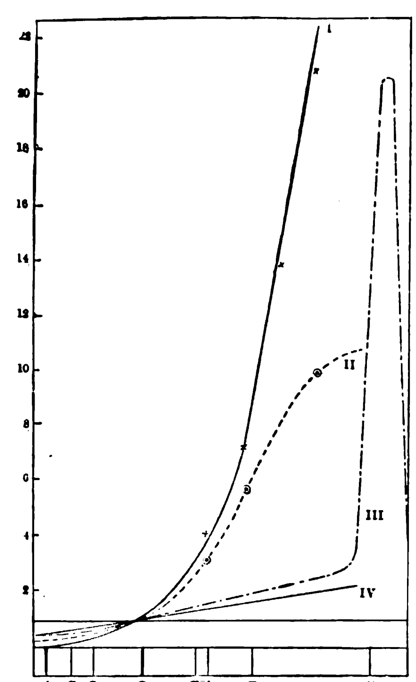


FIG. 8.

growing steadily as the wave length diminishes from the red to the violet end of the spectrum. Figure 8 shows the results of comparisons of the spectra of the lime light, electric arc, and of daylight, by clear and by unclouded sky, with that of an incandescent lamp maintained at its normal candle-power. This lamp, which was chosen as a

13. Edward L. Nichols and W. S. Franklin. A Spectrophotometric Comparison of Artificial Sources of Illumination. Paper read before Section B.; A. A. A. S. at the Cleveland meeting, August, 1888.

standard of comparison, was an Edison 16-candle, 100 volt lamp. Its light was precisely similar to that of a "Board of Trade" argand gas burner, showing the same relative brilliancy throughout the whole of the visible spectrum. The measurements were made with the spectrophotometer just described (see figure 7), the light in every case falling upon the block of magnesium carbonate, and entering the slit of the spectroscope after reflection from the face of the latter. For purpose of comparison the brightness of the standard incandescent lamp has been taken as unity throughout the spectrum. If we make a diagram in which abscissæ are wave-lengths and ordinates, intensities, referred to that of the standard as unity, the curve for this lamp will be a straight horizontal line, with ordinate = 1.

All other spectra are reduced to the same brightness in the region of the D line of Fraunhofer, and their brightness in other regions, referred to that of the corresponding wave length in the spectrum of the standard, is shown by means of curves.

Observations were made in ten regions of the spectrum, equi-distant as to wave length, and embracing the whole of the visible spectrum. It will be seen by reference to the figure that the lime light is relatively much stronger in the violet and much weaker in the red than the standard. In the arc light this increase of intensity toward the violet is even more marked, but its variation in quality from the lime light is by no means so great, as its exceedingly brilliant, bluish-white appearance to the eye would lead us to expect. The source of that appearance and of the very high actinic value of the arc is found, however, in the presence of an exceedingly bright band in the extreme violet. Here the relative intensity of the arc light spectrum rises abruptly about 3 to 20 times that of the incandescent lamp.

Measurements were made upon a long arc lamp with ½-inch carbons, with 10 amperes and 50 volts and a short arc lamp with a 20 ampere current. The character of the light was found to be almost identical excepting in this light band in the neighborhood of the G line, which is much more prominent in the long arc lamp. The character of the light was found to be much the same at all angles below the horizontal plane.

The only other spectrophotometric measurements of the electric arc with which I am acquainted, have been made upon the Foucault regulator, a lamp with carbons of small diameter. Fairly concordant determinations of the distribution of intensities in the spectrum of this lamp by W. H. Pickering,[14] H. C. Vogel,[15] and Crova,[16] show that the light of this lamp is decidedly bluer than that of the lamps with large carbons in vogue at the present day; the spectrum of the former being about five times as rich in the violet as that of gas or oil flames. Mr. Nakano's results, of which mention has already been made, indicate marked increase in the efficiency of the arc lamp, as the diameter of the carbons is decreased; and since increase of efficiency arises from a higher average degree of incandescence, we should expect just such an increment in the shorter wave lengths as shows itself in the case of the Foucault regulator.

Finally, in the case of daylight we find the intensity of the shorter wave lengths exceedingly great as compared with that of any artificial source of illumination. If the spectrum of daylight be brought into comparison with that of an incandescent lamp, and the two be reduced to the same intensity in the yellow, the extreme red of the daylight spectrum will be so *dim* in comparison with that of the lamp as to render measurements difficult. In the violet the discrepancy will be just as marked, the sun's spectrum being relatively of enormous brilliancy. Curve i., figure 8, shows the result of such a measurement of the daylight spectrum, taken just after noon upon a cloudless summer day.

Vogel has given data of a determination in which the preponderance in the violet was even more marked, the relative intensity of daylight for the region corresponding to wave length, 4,260 (just beyond the G line), being 100 : 1 for spectra which were equally bright in the neighborhood of the D line.

Ordinarily, there is considerable absorption of the blue and violet by moisture in the atmosphere, and a measurement of daylight under a densely clouded sky gave curve ii. Even under these conditions, with the violet reduced to about one-tenth of the value which it possesses in clear weather, daylight is very much bluer than any artificial light. The light emitted by burning magnesium approaches more nearly to it than any other, being, according to Pickering, considerably stronger throughout the blue and violet than the light from the Foucault arc lamp. Its color, however, is not reinforced by a violet band like that in the spectrum of the electric arc, a region which, by its extraordinary brightness, has marked influence upon the color of the light.

These variations depend upon temperature primarily, and they may be studied to the best advantage in the spectrum of the incandescent lamp. The radiating surface of such a lamp is at a nearly constant temperature throughout, and it may be given a very considerable range in the matter of incandescence, involving variations in color and total intensity, which are under complete control.

An Edison lamp, similar to that which had been used as a standard in our previous measurements, was subjected to spectrophotometric analysis by Mr. Franklin and myself, at 4 candles, 10 candles, 16 candles, 22 candles and 28 candles, successively. The results obtained are shown in figure 9.

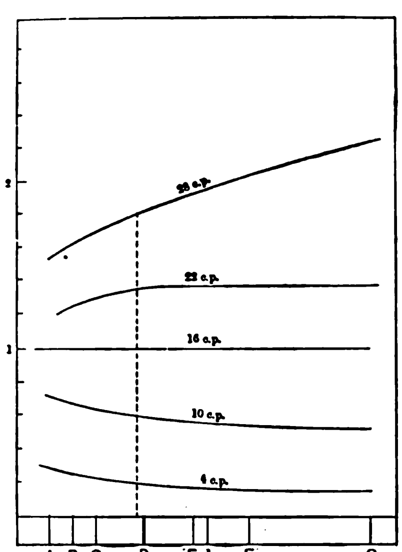


FIG. 9.

The spectrum of the lamp at 16 candles is taken as of unit brightness throughout, and the other curves show the amount of light of each wave length emitted by the lamp in the above-mentioned states of incandescence. Intensities, in every case, are referred to the light of corresponding wave length, given by the same lamp at 16 candles, as unity.

At the red end of the spectrum the intensity increases more slowly than candle-power; at the violet end more rapidly. There exists an intermediate wave length for which the brightness is proportional to the candle-power. The vertical line in the diagram shows the portion of the spectrum for which this holds true, a point in the yellow at wave length 6,000.

14. W. H. Pickering, *l. c.*

15. H. C. Vogel, *l. c.*

16. A. Crova, *l. c.*

If we suppose the same measurements executed upon a set of lamps in every respect similar to the one in question, excepting that their radiating surfaces are of such size that they give 16 candles, as indicated by the Bunsen photometer when the degree of incandescence corresponds respectively to that at which the lamp actually measured emitted at 4, 10, 16, 22, and 28 candles, there would result a set of curves of the same general character as those in figure 12. At wave length 6,000 these curves would have a common value, and they would serve to indicate both the quantity and quality of the variation of the carbon filament, as a function of the incandescence, candle-power remaining constant. The form of these curves is shown in figure 10. They afford us data for discussion of the

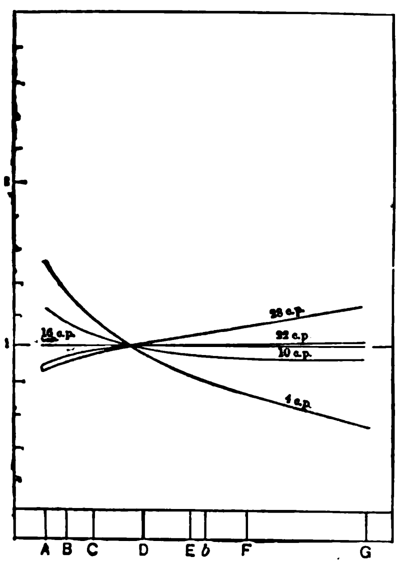


Fig. 10.

candle as a standard of illumination which could not be obtained in any other way. They show the relative distribution of energy in the spectrum of five lamps, which, according to the indications of the Bunsen photometer, are of equal brightness, but which differ both in the quality and in the total energy of their luminous radiation. Their efficiency expressed in terms of the candle-power produced per watt expressed in the lamp, rises rapidly as the incandescence increases. For lamps of the type upon which these measurements were made, for instance, the relative efficiency referred in each case to that of the lamp, the incandescence of which corresponds to that of an Edison lamp at 16 candles, is given in the column headed $\frac{\text{Candle-power}}{\text{Watts.}}$ in table vii.

Table VII.

State of incandescence equivalent to that of an Edison 16-candle lamp giving—	Relative efficiency referred to that of a 16-candle lamp as unity.	
	Candle-power. / Watts.	Luminous radiation. / Total radiation.
(1) 4 candles............	.394	.211
(2) 10 "	.729	.632
(3) 16 "	1.000	1.000
(4) 22 "	1.218	1.368
(5) 28 "	1.391	1.589

If, however, we retain as the measure of efficiency, the ratio, $\frac{\text{luminous radiation}}{\text{total radiation}}$, we can deduce from these curves values coinciding with those reached by the method of the thermopile and alum cell. To this end we must know the above-mentioned ratio for some one candle-power and the number of watts necessary to the production of each state of incandescence for which the computation is to be made.

The relative efficiency can then be calculated from the areas inclosed by the respective curves. Were the candle-power proportional to the energy of luminous radiation, the values thus obtained would be identical with the relative efficiency determined from the relation of candle-power to watts. The relative efficiency thus computed (see table vii.) does not coincide with that obtained from the ratio of watts to candle-power, however, for the reason that the various rays which make up the visible spectrum do not enter into the production of candle-power in proportion to their energy. The most important wave lengths, so far as light-giving power is concerned, are those which form the yellow of the spectrum, and the relative luminosity falls off rapidly both toward the red and the violet. The longer wave lengths have, however, much more influence upon candle-power than the more refrangible rays, as will be seen by an inspection of the curves, the relative falling off of the red end of the spectrum being compensated by larger and larger accessions in the blue and violet as the state of incandescence increases.

Luminosity is the factor, which we must take into account in seeking a complete expression for the efficiency of any source of illumination, and the method to be pursued in the determination of the luminosity must depend upon the use to which the light is to be applied. If we estimate light by its power of bringing out the colors of natural objects, the value which we place upon the blue and violet rays must be very different from that which would be ascribed to them if we consider merely its power of illumination as applied to black and white. In a picture gallery, for instance, or upon the stage, the value of an illuminant increases with the temperature of the incandescent material, out of all proportion to the candle-power, whereas candle-power affords an excellent measure of the light to be used in a reading room.

A number of determinations of the luminosity of artificial light have been made. In the earliest of these by Vierordt,[17] the amount of white light which may be mixed with each color of the spectrum, without producing an appreciable change of tint, was taken as the measure of the luminosity of that color. The result is shown graphically in figure 11. The curve indicates the light-giving

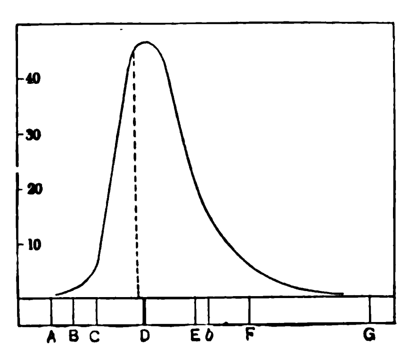


Fig. 11.

power of each wave length, estimated in the above manner. The source of light experimented upon was a petroleum flame. The vertical line indicates the region of the spectrum within which—according to the measurements of the quality of light of the incandescent lamp already described—the increase in the brightness of the spectrum is proportional to the candle-power. This region corresponds very nearly with that of maximum luminosity of the spectrum.

17. C. Vierordt, *Annalen der Physik und Chemie*, Bd. 137, p. 200.

The luminosity of the blue and violet rays is so very small that in the production of *candle-power* the influence of the very rapid growth of this end of the spectrum with increasing temperature of the lamp is scarcely appreciable. If we estimate the light-giving value of the different portions of the spectrum by means of the facility with which we can distinguish black characters upon a white ground, the importance of the more refrangible rays is still farther diminished. Thus Macé de Lepinay and Nicati[18] have shown that if yellow and blue light, estimated to be of equal brightness by photometric means, are of such intensity that one can clearly distinguish a printed page when illuminated by the yellow, the same page will be entirely illegible, when the blue light alone falls upon it. These observers conclude, indeed, that "The mere distinguishing of objects is due almost exclusively to the illumination produced by the less refrangible half of the normal spectrum ;" so that at equal brilliancy "the superiority of yellow sources of light (luminous gas flames, incandescent lamps) over sources richer in blue rays (light of the electric arc) is incontestible." "The only real advantage," they add, "upon the side of the light from the electric arc is when one desires to rehabilitate objects more nearly in the hues which they present in the light of day." This single advantage is one which it is impossible to take due account of, numerically, in an estimate of the efficiency of artificial illumination. It is nevertheless a most important factor in determining the adaptability of a light to nearly all the purposes of everyday life.

Otto Schumann,[19] to whom we owe a most exhaustive study of the light of the incandescent lamp, has determined the luminosity of several types of such lamps at various stages of incandescence. His results, in so far as they apply to a 16-candle Edison lamp, are given in table viii.

TABLE VIII.

Luminosity of an Edison lamp of various stages at incandescence, according to Otto Schumann.

Amperes.	Volts.	Watts.	Luminosity of various regions of the spectrum.						
			Red = λ 676	Orange λ 656	Yellow λ 615	Green λ 557	Blue λ 487	Indigo λ 464	Violet λ 429
0.625	87.3	54.6	1.18	4.64	.....	20.14	0.64	0.11	......
.678	90.4	61.3	1.68	6.66	....	30.35	1.05	0.20	......
.727	94.7	68.8	2.24	9.34	53.11	50.05	1.71	0.34	......
.748	97.4	72.9	2.59	10.92	63.28	62.23	2.24	0.47	......
.823	105.0	86.4	4.06	17.14	99.22	104.3	4.09	0.88	......
.944	112.9	106.7	6.97	28.85	163.0	189.1	7.88	1.75	......
1.009	117.6	118.6	8.74	37.14	222.6	255.7	11.62	2.71	0.42
1.035	120.4	124.7	9.36	41.67	263.8	317.7	16.04	3.79	0.60
1.099	124.5	136.4	11.43	52.36	345.2	472.2	26.24	6.53	1.04

I have made these values of Schumann's the basis of a set of curves, by means of which the variation in luminosity, with total energy in watts, is exhibited (see figure 12). It will be seen that the position of the maximum moves slightly towards the violet as the brightness of the lamp increases. This tendency is very slight within the range of temperatures reached by the incandescent lamp. In the arc light we should find the displacement more marked, but in the case of sunlight, in which, as we have seen, the shorter wave lengths are in such preponderance, the movement of the maximum is inconsiderable. The curves shown in figure 13 are taken from the investigation by Crova, who has determined the distribution of luminosities in the spectrum of sunlight and of the flame of a petroleum lamp. The maximum in sunlight is at $\lambda = 582$, that of the petroleum $\lambda = 592$. Nearly all sources of illumination will be found to have a maximum lying between these two wave lengths.

A comparison of the total luminosity of the incandescent lamp with its candle-power shows that the former increases with the energy of the lamp more rapidly than the latter, although the discrepancy is not so marked as in the comparison of efficiency of candle-power with that of luminous radiation.

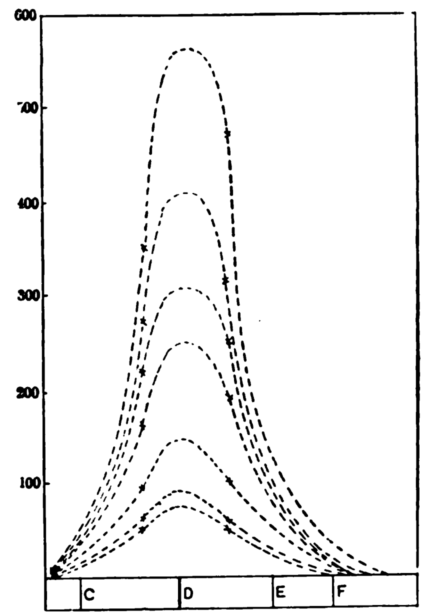


FIG. 12.

The following table, obtained by the summation of the luminosity curves, shows the relation between candle-power and total luminosity, in the case of the lamp studied by Schumann :—

TABLE IX.

Candle-power and total luminosity of the incandescent lamp.

Watts.	Candle-power.	Total luminosity.
54.6	......	4.11
61.3	......	6.31
68.8	10.12	10.20
72.9	12.05	12.58
86.4	18.80	20.64
106.7	31.60	36.80
118.6	41.44	49.77
124.7	50.16	60.85
136.4	64.15	......

Plainly then, candle-power does not afford a measure either of the light-giving energy or of the luminosity of a source of illumination. When used in the comparison of

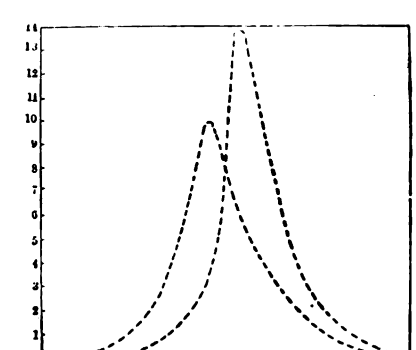


FIG. 13.

sources which differ in temperature, the indications of the photometer always yield us relatively too low a value for the intensity of the lamp of higher incandescence. In the case of candles *vs.* gas, or of either of these in comparison with the incandescent lamp at normal temperature, the

18. Macé de Lepinay and W. Nicati, *Journal de Physique*, second line, T. 2, p. 75, 1883.

19. Otto Schumann, *Elektrotechnische Zeitschrift*, Bd. 5, p. 224, 1884.

error is not important, but between the candle and the "16-candle" lamp maintained at 50 candle-power, the discrepancy amounts to 10 per cent. For the electric arc the ratio of candle-power to total luminosity is very nearly 4 : 5, and in the case of daylight it is about 4 : 6.

In arc light photometry, candle-power is already a well-nigh meaningless term. Would it not be well to abandon it altogether in favor of some standard affording us an expression for the luminosity of radiation? So far as the incandescent lamp is concerned, light-giving power is a perfectly definite function of the temperature and of the area of the radiating surface. We are unfortunately not in position at the present day to measure the temperature of an incandescent filament, but the time will undoubtedly come when the relation between the temperature and the quality of the light emitted by glowing carbon will be definitely known. We may indeed look forward to the development of some optical method for the measurement of the temperature of incandescence which shall be as easily performed as our present method of determining candle-power, and which shall admit of a much higher degree of precision. The comparison of lamps, the temperatures of which are the same, will then reduce itself to a question of radiating surface. Total luminosity and total energy of luminous radiation, per unit of surface, together with net and gross efficiency, may then be expressed, in so far as incandescent carbon is our source of illumination, as functions of the temperature alone, and the performance of any lamp may be defined in terms which admit of no uncertainty.

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.[1]

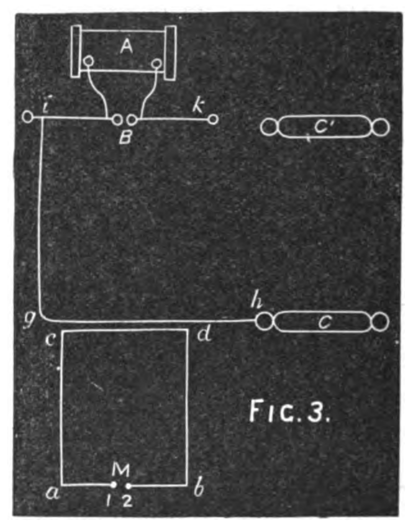
BY G. W. DE TUNZELMANN, B. SC.

(Continued from page 63.)

Induction phenomena in open circuits.—In order to test more fully his conclusion that the sparks obtained in the experiments described in my last paper were due to self-induction, Dr. Hertz placed a rectangle of copper wire with sides 10 and 20 centimeters in length respectively, broken by a short air space, with one of its sides parallel and close to various portions of the secondary circuit of the coil, and of the micrometer circuit, with solid dielectrics interposed, to obviate the possibility of sparking across, and he found that sparking in this rectangle invariably accompanied the discharges of the induction coil, the longest sparks being obtained when a side of the rectangle was close to the discharger.

A copper wire, *i g h* (figure 3), was next attached to the discharger, and a side of the micrometer circuit, which was supported on an insulating stand, was placed parallel to a portion of this wire, as shown in the diagram. The sparks at M, were then found to be extremely feeble until a conductor, C, was attached to the free end, *h*, of the copper wire, when they increased to one or two millimeters in length. That the action of C was not an electrostatic one was shown by its producing no effect when attached at *g* instead of at *h*. When the knobs of the discharger B were so far separated that no sparking took place there, the sparks at M were also found to disappear, showing that these were due to the sudden discharges and not to the charging current. The sparks at the discharger which produced the most effect at the micrometer were of the same character as those described in my last paper. Sparks were also found to occur between the micrometer circuit and insulated conductors in its vicinity. The sparks became much shorter when conductors of larger capacity were attached to the micrometer knobs, or when these were touched by the hand, showing that the quantity of electricity in motion was too small to charge these conductors to a similarly high potential. Joining the micrometer knobs by a wet thread did not perceptibly diminish the strength of the sparks. The effects in the micrometer circuit were not of sufficient strength to produce any sensation when it was touched or the circuit completed through the body.

In order to obtain further confirmation of the oscillatory nature of the current in the circuit *k i h g* (figure 3), the conductor C was again attached to *h*, and the micrometer knobs drawn apart until sparks only passed singly. A second conductor, C′, as nearly as possible similar to C, was then attached to *k*, when a stream of sparks was immediately observed, and it continued when the knobs were drawn still further apart. This effect could not be ascribed to a direct action of the portion of circuit *i k*, for in this case the action of the portion of circuit *g h* would be weakened, and it must therefore have consisted in C′ acting on the discharging current of C, a result which would be quite incomprehensible unless the current in *g h* were of an oscillatory character.



Since an oscillatory motion between C and C′ is essential for the production of powerful inductive effects, it will not be sufficient for the spark to occur in an exceedingly short time, but the resistance must at the same time not exceed certain limits. The inductive effects will therefore be excessively small if the induction coil included in the circuit C C′ is replaced by an electrical machine alternately charging and discharging itself, or if too small an induction coil is used; or, again, if the air space between the discharger knobs is too great, as in all these cases the motion ceases to be oscillatory.

The reason that the discharges of a powerful induction coil gives rise to oscillatory motion is that, firstly, it charges the terminals C and C′ to a high potential; secondly, it produces a sudden spark in the intervening circuit; and, thirdly, as soon as the discharge begins the resistance of the air space is so much reduced as to allow of oscillatory motion being set up. If the terminal conductors are of very large capacity, for example, if the terminals are in connection with a battery, the current of discharge may indefinitely reduce the resistance of the air space, but when the terminal conductors are of small capacity this must be done by a separate discharge, and therefore, under the conditions of the author's experiments, an induction coil was absolutely essentialy for the production of the oscillations.

As the induced sparks in the experiment last described were several millimeters in length, the author modified it by using the arrangement shown in figure 4, and greatly increasing the distance between the micrometer circuit and the secondary circuit of the induction coil. The terminal conductors C and C′ were three meters apart, and the wire

1. From the *Electrician* (London.)

between them was of copper, 2 millimeters in diameter, with the discharger B at its centre.

The micrometer circuit consisted, as in the preceding experiments, of a rectangle 80 centimeters broad by 120 centimeters long. With the nearest side of the micrometer circuit at a distance of half a millimeter from C B C′ sparks two millimeters in length were obtained at M, and though the length of the sparks decreased rapidly as the distance of the micrometer circuit was increased, a continuous stream of sparks was still obtained at a distance of one and one-half meters. The intervention of the observer's body between the micrometer circuit and the wire C B C′ produced no visible effect on the stream of sparks at M. That the effect was really due to the rectilinear conductor C B C′ was proved by the fact that when one or other, or both halves of this conductor were removed, the sparks at M ceased. The same effect was produced by drawing the knobs of the discharger B apart until sparks ceased to pass, showing that the effect was not due to the electrostatic potential difference of C and C′, as this would be increased by separating the discharger knobs beyond sparking distance.

The closed micrometer circuit was then replaced by a straight copper wire, slightly shorter than the distance C C′ placed parallel to C B C′, and at a distance of 60 centimeters from it. This wire terminated in knobs, 10 centimeters in diameter, attached to insulating supports, and the spark micrometer divided it into two equal parts. Under these circumstances, sparks were obtained at the micrometer, as before.

With the rectilinear open micrometer circuit sparks were still observed at the micrometer when the discharger

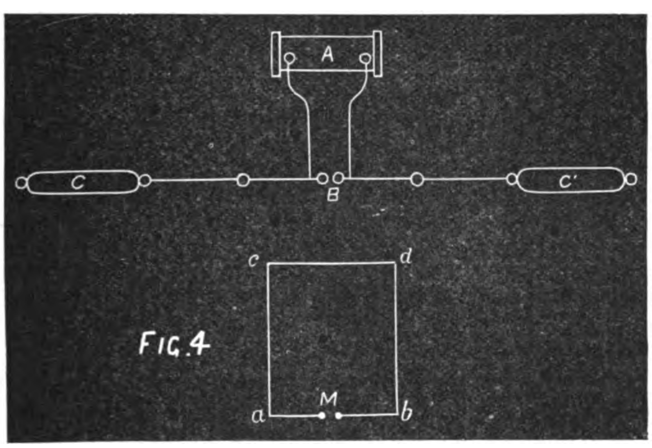


FIG. 4

knobs of the secondary coil circuit were separated beyond sparking distance. This was, of course, due simply to electrostatic induction, and shows that the oscillatory current in C C′ was superposed upon the ordinary discharges. The electrostatic action could be got rid of by joining the micrometer knobs by means of a damp thread. The conductivity of this thread was therefore sufficient to afford a passage to the comparatively slow alternations of the coil discharge, but was not sufficient to provide a passage for the immeasurably more rapid alternations of the oscillatory current. Considerable sparking took place at the micrometer when its distance from C B C′ was 12 meters, and faint sparks were distinguishable up to three meters. At these distances it was not necessary to use the damp thread to get rid of the electrostatic action, as, owing to its diminishing more rapidly with increase of distance than the effect of the current induction, it was no longer able to produce sparks in the micrometer, as was proved by separating the discharger knobs beyond sparking distance, when sparks could no longer be perceived at the micrometer.

Resonance phenomena.—In order to determine whether, as some minor phenomena had led the author to suppose, the oscillations were of the nature of a regular vibration, he availed himself of the principle of resonance. According to this principle, an oscillatory current of definite period would, other conditions being the same, exert a much greater inductive effect upon one of equal period than upon one differing even slightly from it.[1]

If, then, two circuits are taken having as nearly as possible equal vibration periods, the effect of one upon the other will be diminished by altering either the capacity or the coefficient of self-induction of one of them, as a change in either of them would alter the period of vibration of the circuit.

This was carried out by means of an arrangement very similar to that of figure 4. The conductor C C′ was replaced by a straight copper wire 2.6 meters in length and five millimeters in diameter, divided into two equal parts as before by a discharger. The discharger knobs were attached directly to the secondary terminals of the induction coil. Two hollow zinc spheres, 30 centimeters in diameter, were made to slide on the wire, one on each side of the discharger, and since, electrically speaking, these formed the terminals of the conductor, its length could be varied by altering their position. The micrometer circuit was chosen of such dimensions as to have, if the author's hypothesis were correct, a slightly shorter vibration period than that of C C′. It was formed of a square, with sides 75 centimeters in length, of copper wire two millimeters in diameter, and it was placed with its nearest side parallel to C B C′, and at a distance of 30 centimeters from it. The sparking distance at the micrometer was then found to be 0.9 millimeter. When the terminals of the micrometer circuit were placed in contact with two metal spheres eight centimeters in diameter, supported on insulating stands, the sparking distance could be increased up to 2.5 millimeters. When these were replaced by much larger spheres the sparking distance was diminished to a small fraction of a millimeter. Similar results were obtained on connecting the micrometer terminals with the plates of a Kohlrausch condenser. When the plates were far apart the increase of capacity increased the sparking distance, but when the plates were brought close together the sparking distances again fell to a very small value.

The simplest method of adjusting the capacity of the micrometer circuit is to suspend to its ends two parallel wires, the distance and lengths of which are capable of variation. By this means the author succeeded in increasing the sparking distance up to three millimeters, after which it diminished when the wires were either lengthened or shortened. The decrease of the sparking distance on increasing the capacity was naturally to be expected; but it would be difficult to understand, except on the principle of resonance, why a decrease of the capacity should have the same effect.

The experiments were then varied by diminishing the capacity of the circuit C B C′ so as to shorten its period of oscillation, and the results confirmed those previously obtained, and a series of experiments in which the lengths and capacities of the circuits were varied in different ways, showed conclusively that the maximum effect does not depend on the conditions of either one of the two circuits, but on the existence of the proper relation between them.

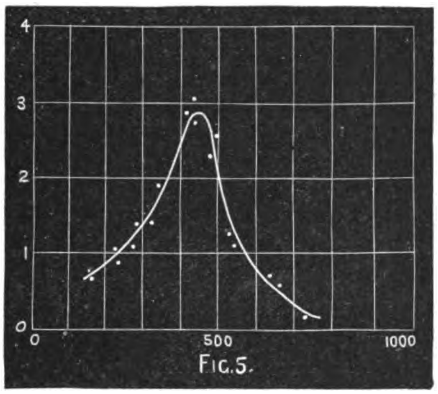
When the two circuits were brought very close together, and the discharger knobs separated by an interval of seven millimeters, sparks were obtained at the micrometer, which were also seven millimeters in length, when the two circuits had been carefully adjusted to have the same period. The induced E. M. F.'s must in this case have attained nearly as high a value as the inducing ones.

To show the effect of varying the coefficient of self-induction, a series of rectangles, *a b c d* (figure 4), were taken, having a constant breadth, *a b*, but a length, *a c*, continually increasing from 10 centimeters up to 250 cen-

1. See Oberbeck, Wiedemann's *Annalen*, vol. xxvi., p. 245, 1885.

timeters; it was found that the maximum effect was obtained with a length of 1.8 meters. The quantitative results of these experiments are shown in figure 5, in which the abscissæ of the curve are the double lengths of the rectangles, and the ordinates represent the corresponding maximum sparking distances. The sparking distances could not be determined with great exactness, but the errors were not sufficient to mask the general nature of the result.

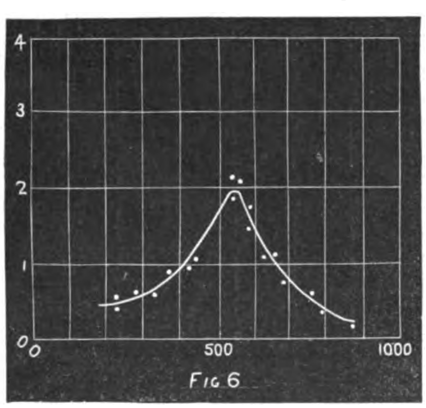
In a second series of experiments the sides *a c* and *b d* were formed of loose coils of wire which were gradually pulled out, and the result is shown in figure 6. It will be



Curve showing relation between length of side of rectangle (taken as abscissa and maximum sparking distance (taken as ordinate), the sides consisting of straight wires of varying lengths.

seen that the maximum sparking distance was attained for a somewhat greater length of side, which is explained by the fact that in the latter experiments the self-induction only was increased by increase of length, while in the former series the capacity was increased as well. Varying the resistance of the micrometer circuit by using copper and german-silver wires of various diameters was found to have no effect on the period of oscillation, and extremely little on the sparking distance.

When the wire *c d* was surrounded by an iron tube, or when it was replaced by an iron wire, no perceptible effect was obtained, confirming the conclusion previously arrived



Curve showing relation between length of side of rectangle (taken as abscissa) and maximum sparking distance (taken as ordinate), the sides consisting of spirals gradually drawn out.

at that the magnetism of the iron is unable to follow such rapid oscillations, and therefore exerts no appreciable effect.

Nodes.—The vibrations in the micrometer circuit which have been considered are the simplest ones possible, but not the only ones. While the potential at the ends alternates betweeen two fixed limits, that at the central portion of the circuit retains a constant mean value. The electrical vibration, therefore, has a node at the centre, and this will be the only nodal point. Its existence may be proved by placing a small insulated sphere close to various portions of the micrometer circuit while sparks are passing at the discharger of the coil, when it will be found that if the sphere is placed close to the centre of the circuit the sparking will be very slight, increasing as the sphere is moved further away. The sparking cannot, however, be entirely got rid of, and there is a better way of determining the existence and position of the node. After adjusting the two circuits to unison, and drawing the micrometer terminals so far apart that sparks can only be made to pass by means of resonant action, let different parts of the circuit be touched by a conductor of some capacity, when it will be found that the sparks disappear, owing to interference with the resonant action, except when the point of contact is at the centre of the circuit. The author then endeavored to produce a vibration with two nodes, and for this purpose he modified the apparatus previously used by adding to the micrometer circuit a second rectangle, *e f g h*, exactly similar to the first (as shown in figure 7), and joining the points of the circuit near the terminals by wires 13 and 24, as shown in the diagram.

The whole system then formed a closed metallic circuit, the fundamental vibration of which would have two nodes. Since the period of this vibration would necessarily agree closely with that of each half of the circuit, and, therefore, with that of the circuit c c′, it was to be expected that the vibration would have a pair of loops at the junctions 13 and 24, and a pair of nodes at the middle points of *c d* and *g h*. The vibrations were determined by measuring the sparking distance between the micrometer terminals 1 and 2. It was found that, contrary to what was expected, the addition of the second rectangle diminished this sparking distance from about three millimeters to about one millimeter. The existence of resonant action between the circuit c c′ and the micrometer circuit was, however, fully demonstrated, for any alteration in the circuit *e f g h*, whether it consisted in increasing or in decreasing its length, diminished the sparking distance. It was also found that much weaker sparking took place between *c d* or *g h* and an insulated sphere, than between *a e* or *b f* and the same sphere, showing that the nodes were in *c d* and *g h*, as expected. Further, when the sphere was made to touch *c d* or *g h* it had no effect on the sparking distance of 1 and 2; but when the point of contact was at any other portion of the circuit the sparking distance was diminished, showing that these nodes did really belong to the vibration, the resonant action of which increased this sparking distance.

The wire joining the points 2 and 4 was then removed. As the strength of the induced oscillatory current should be zero at these points the removal ought not to disturb the vibrations, and this was shown experimentally to be the case, the resonant effects and the position of the nodes remaining unchanged. The vibration with two nodal points was, of course, not the fundamental vibration of the circuit, which consisted of a vibration with a node between *a* and *e*, and for which the highest values of the potential were at the points 2 and 4.

When the spheres forming the terminals at these points were brought close together slight sparking was found to take place between them, which was attributed to the excitation, though only to a small extent, of the fundamental vibration. This explanation was confirmed in the following manner:—The sparks between 1 and 2 were broken off, leaving only the sparks between 2 and 4, which measured the intensity of the fundamental vibration. The period of vibration of the circuit c c′ was then increased by drawing it out to its full length, and thereby increasing its capacity, when it was observed that the sparking gradually increased to a maximum, and then began to diminish again. The maximum value must evidently occur when the period of vibration of the circuit c c′ is the same as that of the fundamental vibration of the micrometer circuit, and it was shown that when the sparking distance between 2 and 4 had its maximum value, the sparks corres-

ponded to a vibration with only one nodal point, for the sparks ceased when the previously existing nodes were touched by a conductor, and the only point where contact could take place without effect on the sparking was between a and e. These results show that it is possible to excite at will in the same conductor, either the fundamental vibration or its first overtone, to use the language of acoustics.

Hertz appears to consider it very doubtful whether it will be possible to get higher overtones of electrical vibration, the difficulty of obtaining such lying not only in the method of observation, but also in the nature of the oscillations themselves. The intensity of these is found to vary considerably during a series of discharges from the coil even when all the circumstances are maintained as constant as possible, and the comparative feebleness of the resonant effects shows that there must be a considerable amount of damping. There are, moreover, many secondary phenomena which seem to indicate that irregular vibrations are superposed upon the regular ones, as would be expected in complex systems of conductors. If, therefore, we wish to compare electrical oscillations, from a mathematical point of view, with those of acoustics, we must seek our analogy in the high notes intermixed with irregular vibrations, obtained say, by striking a wooden rod with a hammer, rather than in the comparatively slow

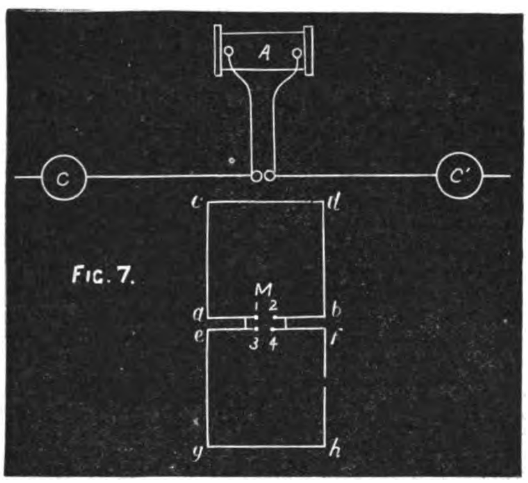


FIG. 7.

harmonic vibration of tuning forks, or strings ; and in the case of vibrations of the former class we have to be contented, even in the study of acoustics, with little more than indications of such phenomena as resonance and nodal points.

Referring to the conditions to be fulfilled in order to obtain the best results, should other physicists desire to repeat the experiments, Dr. Hertz notes a fact of very considerable interest and novelty, namely, that the spark from the discharger should always be visible from the micrometer, as when this was not the case, though the phenomena observed were of the same character, the sparking distance was invariably diminished. This effect of the light from the spark of an induction coil in increasing the sparking distance in the secondary circuit of another coil excited great interest when referred to by Professor Lodge in the course of the recent discussion on Lightning Conductors at the British Association, and he pointed out that the same effect was produced by light from burning magnesium wire, or other sources rich in the ultra violet rays.

Theory of the experiments.—The theories of electrical oscillations which have been developed by Sir William Thomson, von Helmholtz and Kirchhoff have been shown[1] to hold good for the open circuit oscillations of induction apparatus, as well as for the oscillatory Leyden jar discharge, and, although Dr. Hertz has not succeeded in obtaining definite quantitative results to compare with theory, it is of interest to inquire whether the observed results are of the same order as those indicated by theory.

1. Lorentz, Wiedemann's *Annalen*, vol. vii., p. 161, 1879.

Hertz considers, in the first place, the vibration period. Let T be the period of a single or half vibration proper to the conductor exciting the micrometer circuit ; P its coefficient of self-induction in absolute electro-magnetic measure, expressed, therefore, in centimeters ; C the capacity of one of its terminals in electrostatic measure, and, therefore, also expressed in centimeters ; and v the velocity of light in centimeter-seconds.

Then, if the resistance of the conductor is small,

$$T = \frac{\pi \sqrt{P C}}{v}.$$

In the case of the resonance experiments, the capacity C was approximately the radius of the sphere forming the terminal, so that $C = 15$ centimeters. The coefficient of self-induction was that of a wire of length $l = 150$ centimeters, and diameter $d = 1/2$ centimeter.

According to Neumann's formula,

$$P = \iint \frac{\cos \varepsilon}{r} d\,s\,d\,s',$$

which gives in the case considered

$$P = 2\,l \left(\log \frac{4\,l}{d} - 0.75 \right) = 1902 \text{ cm.}$$

As, however, it is not quite certain that Neumann's formula is applicable to an open circuit, it is better to use von Helmholtz's more general formula, containing an undetermined constant, k according to which

$$P = 2\,l \left(\log \frac{4\,l}{d} - 0.75 + \frac{1-k}{2} \right).$$

Putting $k = 1$ this reduces to Neumann's formula, for $k = 0$ it reduces to that of Maxwell, and for $k = -1$ to Weber's. The greatest difference in the values of P obtained by giving these different values to k would not exceed a sixth of its mean value, and, therefore, for the purposes of the present approximation it is enough to assume that k is not a large positive or negative number ; for if the number 1,902 does not give the correct value of the coefficient for the wire 150 cm. in length, it will give the value corresponding to a conductor not differing greatly from it in length.

Taking $P = 1902$ cm. we have $\pi \sqrt{C P} = 531$ cm., which represents the distance traversed by light during the oscillation, or, according to Maxwell's theory, the length of an electro-magnetic ether wave. The value of T is then found to be 1.77 hundred millionths of a second, which is of the same order as the observed results.

The ratio of damping is then considered. In order that oscillations may be possible the resistance of the open circuit must be less than $2\,v\,\sqrt{P/C}$. For the exciting circuit used this gives 676 ohms as the upper limit of resistance. If the actual resistance r is sensibly below this limit, the ratio of damping will be $e^{\frac{r\,T}{2\,P}}$. The amplitude will therefore be reduced in the ratio 1 : 2.71 in

$$\frac{2\,P}{r\,T} = \frac{2\,v}{\pi\,r}\sqrt{\frac{P}{C}} = \frac{676}{\pi\,r} = \frac{215}{r}$$

oscillations. We have, unfortunately, no means of determining the resistance of the air space traversed by the spark, but as the resistance of a strong electric arc is never less than a few ohms we shall be justified in assuming this as the minimum limit. From this it would follow that the number of oscillations due to a single impulse must be reckoned in tens, and not in hundreds or thousands, which is in accordance with the character of the experimental results, and agrees with the results observed in the case of

the oscillatory Leyden jar discharge. In the case of closed metallic circuits, on the other hand, theory indicates that the number of oscillations before equilibrium is attained must be reckoned by thousands.

Hertz compares, lastly, the order of the inductive actions of these oscillations, according to theory, with that of the effects actually observed. To do this it must be noted that the maximum E. M. F. induced by the oscillation in its own circuit is approximately equal to the maximum potential difference at its extremities; for if there were no damping these quantities would be identical, since at any moment the potential difference at the etxremities and the E. M. F. of induction would be in equilibrium. In the experiments under consideration the potential difference at the extremities was such as to give a spark 7 to 8mm. in length, which must therefore represent the maximum inductive action excited in its own circuit by the oscillation. Again, at any instant the induced E. M. F. in the micrometer circuit must be to that in the exciting conductor in the same ratio as that of the coefficient of mutual induction p of the two circuits to the coefficient of self-induction P of the exciting circuit. The value of p for the case considered is easily calculated from the ordinary formulæ, and it is found to lie between one-ninth and one-twelfth of P. This would only give sparks of from $\frac{1}{2}$ to $\frac{2}{3}$ mm. in length, so that according to theory visible sparks ought in any case to be obtained; but, on the other hand, sparks several millimeters in length, as were obtained in the experiments previously described, can only be explained on the assumption that the successive inductive actions produce an accumulative effect; so that theory indicates the necessity of the existence of the resonant effects actually observed.

(*To be continued.*)

THE WIRES MUST GO UNDERGROUND.

Regular meeting of the Board of Electrical Control, Mayor Grant in the chair.

Mayor Grant (to an officer of the electric light company, who is summoned before the Board)—Has your company yet complied with the law requiring them to put their wires in the conduits?

Electric Light Man (innocently)—What conduits?

Mayor—The conduits laid underground to receive them.

E. L. Man (surprised tone)—Have they been laying conduits?

Mayor (sternly)—You know they have.

E. L. Man (suddenly recollecting)—Oh, yes, seems to me I did hear something about it last summer.

Mayor—Your company has promised repeatedly to bury the wires.

E. L. Man (with a puzzled look)—Bury what wires?

Mayor (impatiently)—Your electric wires, of course.

E. L. Man—Bury them before they are dead?

Mayor (with rising indignation)—We'll have no more trifling in this matter.

E. L. Man—I never trifle with an electric wire, especially when it is alive, your Honor.

Mayor (consulting his notes)—Over a year ago you were given sixty days to put your wires underground. Why didn't you do it?

E. L. Man (after reflecting)—I think it rained.

Mayor—Then your time was extended sixty days more. Why wasn't it done then?

E. L. Man—Why wasn't what done?

Mayor (emphasizing each word by a tap of his pencil on the table)—Why—didn't—you—put—the—wires—under—ground?

E. L. Man—Oh, why didn't we? Well, we didn't know that they wanted to be put underground.

Mayor (getting mad)—We'll have no more fooling; the poles must come down.

E. L. Man—What poles?

Mayor—Don't your company have poles?

E. L. Man—Oh, yes. Now and then one, more for ornament than anything else.

Mayor (getting ugly)—Well, if those poles are not down and the wires underground in thirty days I will know the reason why.

The Electric Light Man bows and saunters off, satisfied that there's no occasion to hurry about it.—*Texas Siftings.*

POINTERS.

.... LIGHT and power are the foundation necessities of civilization.—*A. R. Foote.*

.... I BELIEVE that nine out of ten workmen, if they are not watched, will make bad joints.—*W. A. Chamen.*

.... ELECTRICAL engineers know well that they must, before all, be engineers. They must be engineers, and they must learn electricity.—*Sir William Thomson.*

.... WITH regard to the insulation of slate bases and fittings, I find that slate may be greatly improved in this respect by soaking it in melted paraffine wax.—*G. C. Fricker.*

.... PORTLAND cement certainly seems to have some deteriorating effect upon insulation.—*W. A. Chamen.*

.... WHAT limits may be found on the practical distribution of electric power is not known. Conditions for its distribution are being learned. When the natural laws governing it are complied with in these conditions, it is known that the world is not large enough to limit its distribution.—*A. R. Foote.*

.... WHAT is chiefly wanted is to ascertain the minimum standard of insulation resistance compatible with good honest work and ordinary careful usage.—*Professor A. Jamieson.*

.... THE limit of the benefit derived from the use of any force is fixed by the power to distribute it cheaply. Of the two factors, the power to *distribute* cheaply is far more potent than the power to *produce* cheaply.—*A. R. Foote.*

.... THE total insulation of a self-contained installation containing a dynamo need not be nearly so high, and consequently need not be treated so carefully, as that of one forming part of a central station system.—*R. E. Crompton.*

.... ELECTRIC light and power will produce more changes in the mechanical servants and conveniences of civilized life than has ever been caused by the use of any other method or force which has been subjected to the service of man.—*A. R. Foote.*

.... THE electrical engineer, or the youth or aspirant to that honorable profession, after having obtained the elements of a good general education, ought to learn mathematics and dynamics well. Then a good deal of chemistry and regular mechanical and civil engineering should all be learned; and electricity besides.—*Sir William Thomson.*

.... IGNORANCE more frequently begets confidence than knowledge; it is those who know little and not those who know much, who so positively assert that this or that problem will never be solved by science.—*Darwin.*

.... IT is no longer a difficult matter to obtain high insulation in every part of dynamo machines. Now that we dynamo makers have had our attention directed to the fact that there are far better varnishes than shellac, there is no difficulty in obtaining any desired degree of insulation on the dynamo itself, from the first moment that it is wound.—*R. E. Crompton.*

.... A FORCE is known by its highest form of expression. Water power is mentioned without reference to the power of gravity. Steam power is referred to without reference to the expansive power of water or heat. Electric power is also spoken of without reference to its underlying forces. It is vitalized by all power. It is the spirit of all force.—*A. R. Foote.*

.... EVERY requirement of sound business management demands that those who build for an investment, shall use only the best apparatus and material for its purpose, and shall construct in the most durable and artistic manner.—*A. R. Foote.*

.... EVERY young person who has a fancy for electricity thinks he would like to be an electrical engineer. He thinks electrical engineering is all ether and electricity. Now I have continually to impress upon anxious fathers and mothers that their boys must condescend to learn something of gross ponderable matter, and that electrical engineering is not confined to ether and electricity, but mechanics also is an essential part of the subject. —*Sir William Thomson.*

.... IT is quite easy, if due precautions are taken, to obtain excessively high insulation on installations of considerable magnitude.—*R. E. Crompton.*

.... THE advent of a new force has never completely abolished the use of the old. In fact, the new is developed by making the old its servant. Water became the servant of steam. Water and steam are the servants of electricity.—*A. R. Foote.*

THE WESTERN ELECTRIC COMPANY'S NEW BUILDING IN NEW YORK.

The New York branch of the Western Electric Company has just been housed in the factory and store building recently completed at the corner of Greenwich and Thames streets. In elegance of appearance, in solidity, and in adaptation to the several requirements of factory, warehouse and offices, the structure may fairly be said to embody the best that skill, knowledge and taste, well supported by wise and liberal expenditure, can devise at the present time.

Since the spring of 1879, when the Western Electric Company established a New York branch through the acquisition of the factory and repair shop of the Western Union Telegraph Co., it has, till the present removal, occupied, on lease, the Western Union factory building on Trinity place (New Church street). Some years ago the steady expansion of the business, both in manufacturing and trading, had made it clear to the officers and directors of the company that provision would soon have to be made for greater facilities. After careful and well matured consideration it was determined to seek a location in the down-town business section not remote from the old factory, and to put up a thoroughly high-class building large enough to permit still further expansion of the works. It became necessary, therefore, to resort to height rather than to a spacious ground plan for obtaining the requisite amount of floor space. How well all has been accomplished will appear, to some extent, in the following description, with the illustrations showing a view of the exterior of the new building and plans of several of the floors.

The Western Electric Company's Building, New York.

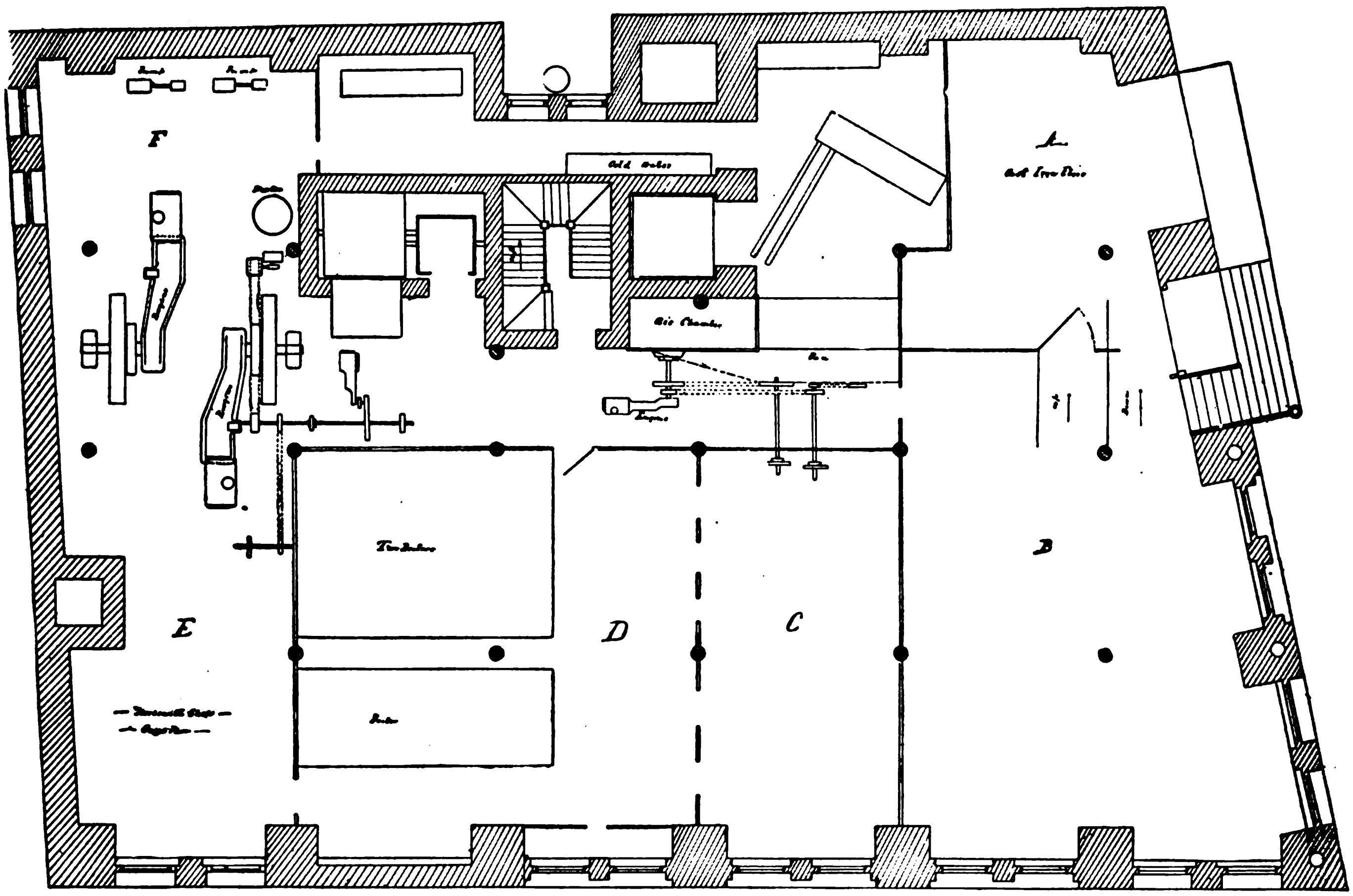
The building has 119 feet frontage on Thames street and 83 feet frontage on Greenwich street. In March, 1888, the ground was occupied by tenement houses, in which there were about fifty families living. About the 1st of April work was commenced, tearing down the old buildings, and in May the work of putting in the foundations was begun. The work on the foundations was delayed by the necessity of shoring up the adjoining buildings, and it was about the 1st of August before any work could be done on the superstructure. By the 1st of November, however, the building was ready for the roof beams; this remarkably quick progress of the building being due largely to the energy of the architect and of Mr. Otto Eidlitz, of Marc Eidlitz & Son, the builders.

The handsome appearance of the building, and the thorough construction of it, are due to the architect, Mr. C. L. W. Eidlitz. Its convenient arrangement for the purposes of the Western Electric Company is largely the work of Mr. W. R. Patterson, of the Chicago house, who, in planning the arrangement of the Chicago shop, gained an experience which admirably fitted him for this work.

The building is as nearly fire-proof in construction as possible, the columns, girders and beams being of iron, and the floors of brick and concrete, covered with one layer of maple. The stairway and elevators are separated from the rest of the building by brick walls and iron doors. In addition to this fire-proof construction the precaution was taken of fire-proofing all of the iron work on the lower floors, in which the wood-working department, store rooms, etc., are located, and of building a fire-proof vault on each floor for the storage of records, tools, patterns, and, especially, valuable finished goods. The principal contractors in the construction of the building were Marc Eidlitz & Son, masons and builders; Post & McCord, iron work; and Thomas Wilson, wood work.

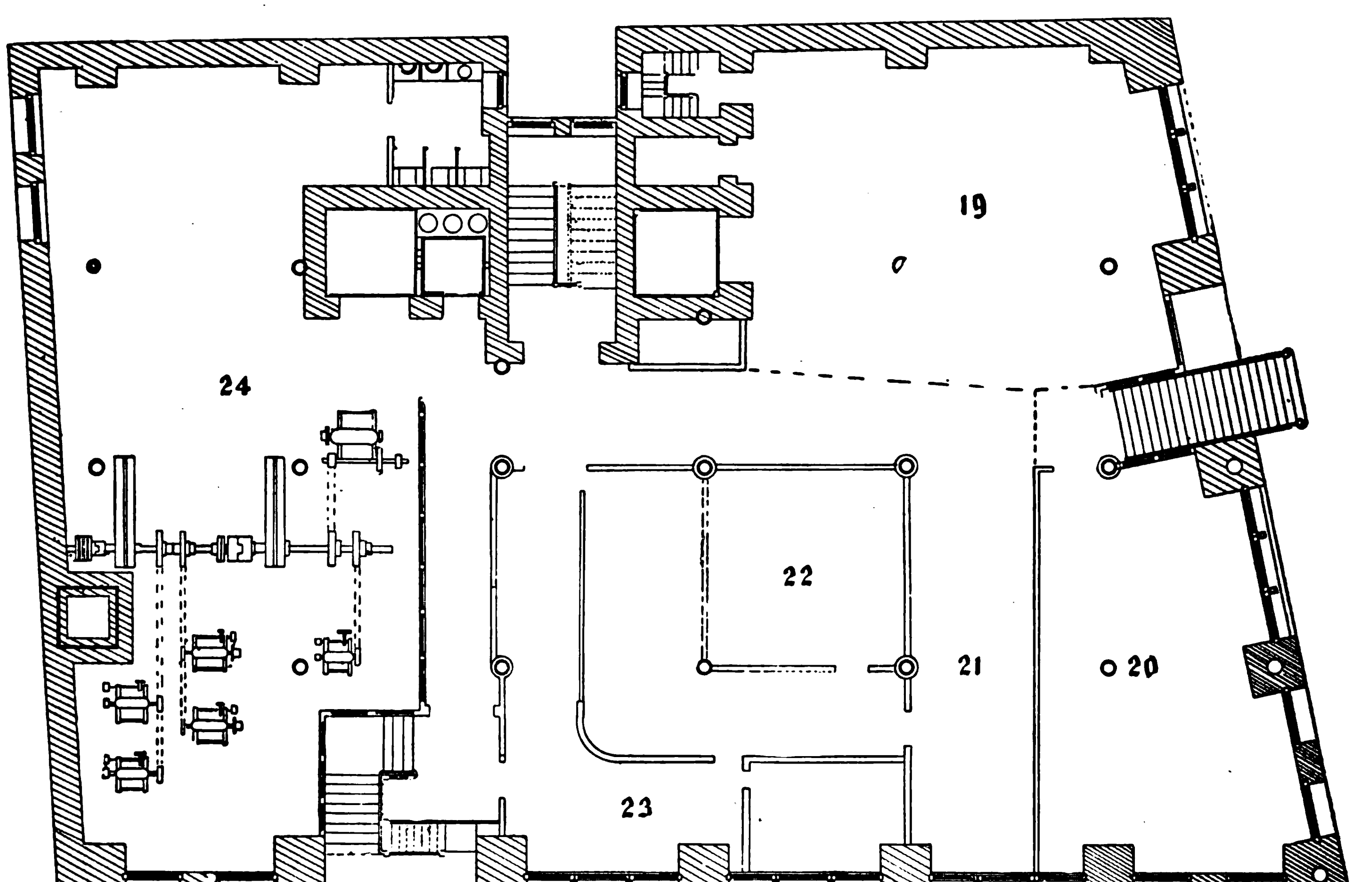
The exterior of the building is of buff brick, of the shade known as Telephone brick, which was used in the construction of the Telephone Building on Cortlandt street. This brick, together with the terra cotta, was furnished by the Perth Amboy Terra Cotta Co.

The entrance to the offices and to the retail store is on Thames street; on Greenwich street is the shop entrance and also the platform for shipping and receiving goods. (See plan of second floor.)



WESTERN ELECTRIC COMPANY'S BUILDING.—BASEMENT (FIRST FLOOR).

A. Foundry Store Room.
B. Foundry.
C. Coal Storage.
D. Boiler Room.
E. Blacksmith Shop.
F. Engine Room.



WESTERN ELECTRIC COMPANY'S BUILDING.—SECOND FLOOR.

19. Packing Room.
20. Nickel-Plating Room.
21. Cable Work Room.
22. Electric House Work Room.
23. Retail Store.
24. Dynamo Room.

In December the building was ready for the steam plant. This consists of three Babcock & Wilcox boilers, two in battery, capable of developing 312 h. p.; and a separate boiler capable of developing 136 h. p. (See plan of basement—first floor.)

The power plant consists of two engines, with cylinders 18 inches in diameter by 27 inches stroke, which, at 125 revolutions per minute, will each develop 175 h. p. Also, one engine with cylinder eight inches in diameter by 12 inches stroke, 35 h. p. The three engines were from Russell & Co., Massilon, O. The power is transmitted to the various floors by rope transmission furnished by the Link Belt Machinery Co., of Chicago; the rope used being made of rawhide. The engine room is equipped with all of the latest improvements in the way of feed-water heaters, pumps, regulators, eliminators, etc.

The heating plant of the building was furnished by B. F. Sturtevant, of Boston, and consists of a heating chamber in the basement, a blower 10 feet by five feet, and a Sturtevant engine, cylinder eight inches in diameter by 12 inch stroke. Cold air is drawn to the heating chamber through a duct terminating three feet above the roof. After passing through the heating chamber it is blown through a hot air duct having openings on the various floors.

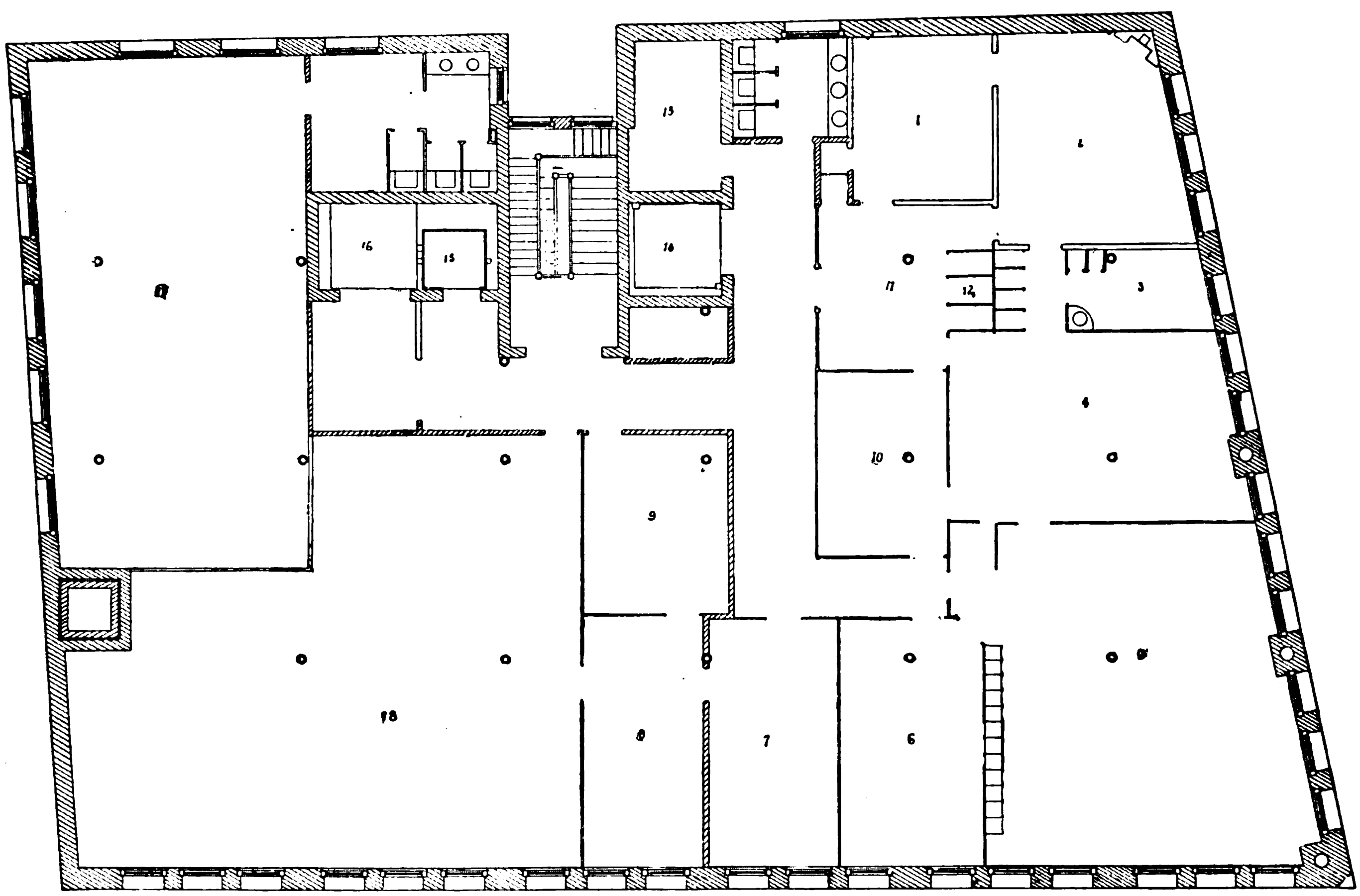
The building is furnished with two worm geared freight elevators and a steam passenger elevator, put in by the Crane Elevator Co. The east freight elevator is for the use of the shop, carrying material and unfinished work from one floor to another; the west freight elevator is intended for the use of the shipping department.

Besides the boiler and engine room there are in the basement (first floor) a blacksmith shop and foundry. Between the basement and the second floor there is, on the Greenwich street side, an intermediate floor at the level of a truck above the sidewalk, to facilitate the shipping and receiving of goods. Directly above it, on the second floor, is the packing room. On this same floor are the nickel plating room, the cable department work room, the retail store, and the electric house work department.

The whole space to the left of the Thames street entrance, which leads directly to the passenger elevator communicating with the offices, is the dynamo room. Here are three 45-light and one 35-light arc dynamos and a 300-light incandescent dynamo, all manufactured by the Western Electric Company, and to be used in lighting the building. On this floor, also, is the main shaft, and the outfit of clutches, so arranged that any one of the four engines in the basement, or any combination of them, can be used for the power, light, or heat which may be necessary.

The third floor is occupied by the wood-working department and by the battery room and chemical laboratory. The fourth floor is used entirely for storage of the various line and other electrical supplies sold but not manufactured by the Western Electric Company. On the fifth floor is the shop office and shop storeroom, and some of the heavier machinery, such as presses, screw machines, planers and engine lathes. The sixth, seventh and eighth floors are for general manufacturing. The ninth floor is used in part for the manufacture of telephones, and in part for inspector's room, where all of the apparatus manufactured is inspected before shipment, and where manufactured goods are stored until shipped.

The eastern half of the tenth floor is occupied by the winding room (in which electro-magnets for the various instruments are wound) and by the work room for the switch-board department. The western half of the tenth floor is occupied by the offices of the New York branch of the company. (See plan of tenth floor.)



Western Electric Company's Building.—Tenth Floor.

1. President's Room.
2. Manager's Room.
3. Stenographers.
4. Salesmen.
5. Counting Room.
6. Cashier's Room.
7. Cable Department.
8. Switch-board Department.
9. Library.
10. Mailing and Filing Room.
11. Waiting Room.
12. Telephone Closets.
13. Fire-Proof Vault.
14. Freight Elevator.
15. Passenger Elevator.
16. Freight Elevator.
17. Winding Room.
18. Switch-board Work-room.

The building is thoroughly equipped with everything in the way of electrical apparatus which facilitates the transaction of business. The various offices and floors are connected by the Western Electric speaking tube telephone system, by means of which connection can instantly be made between one room and another without the aid of a central office or switch-board. In the waiting room of the general office are three telephone closets, in one of which is one of these speaking tube telephones, and in the other two a long-distance telephone instrument and a metallic circuit city telephone.

A room opening out of the offices is being fitted up as a library, where there will be as complete a collection as possible of books and periodicals for the use of the employés

The location of the offices on the top floor of the lofty building is characteristic of the excellent judgment shown in the arrangement of the entire structure. The tenth floor is so far above the street level as to secure to the staff and clerks immunity from the noise and dust of the crowded thoroughfare below, and it is so high above the neighboring roofs that abundant sunlight and air has access on every side. The room occupied by the manager, Mr. H. B. Thayer, at the south-west corner, and the adjoining room—for the use of the president, Mr. E. M. Barton, and the secretary and treasurer, Mr. J. M. Jackson, when in New York—can hardly be surpassed in the city for their outlook over the surrounding town, waterways and country. The rooms of the purchasing agent, cashier, heads of departments, salesmen and clerks are hardly less pleasant, and are very commodious and handsome in their appointments.

The work rooms, most of them being on the upper floors, are unusually well provided with air and light for a factory situated in the down-town district.

This elegant and thoroughly equipped building, with the large and still growing business now to be conducted within its walls, must be regarded as an important contribution to the industrial growth of New York.

ABSTRACTS AND EXTRACTS.

THE RIVAL ALTERNATING CURRENT DISTRIBUTING SYSTEMS IN LONDON.

Being, as we believe, on the eve of a great development in central station work, it may be useful to review briefly the present position of this industry. The generation of electricity, and its utilization in suitable lamps, are problems which are now satisfactorily solved, but its transmission from the station to the customers' houses and its storage are still open questions, and various rival systems are now, or shortly will be, clamoring for public favor. It is an easy matter to determine the merits of any particular dynamo, battery, motor, or lamp; but problems connected with the distribution of current throughout an extended district cannot be solved in the laboratory or the workshop, and a solution to such problems can only be found by experiments on a large scale. Such experiments are very costly, and, if unsuccessful, must entail an enormous amount of inconvenience on the users or would-be users of the electric light. In alternate current distribution there are now, broadly speaking, two rival systems in the field—the one modeled on the method of supply adopted by large gas companies, and the other an extension of the plan adopted in low tension direct current stations. In the first system the current required for the whole district is generated at a single gigantic station situated outside the area to be lighted, whilst in the second system this area is sub-divided into several sections, each having its own central station, either within its own boundary or as close to it as possible. Both these plans are to be tried in London—the first by the London Electric Supply Corporation, Limited, whose Deptford station will form a counterpart to the Beckton Gas Works; and the second by the Metropolitan Electric Supply Co., Limited, who also propose to serve the whole of London, but from many smaller central stations, so distributed that the maximum distance to any customer should not exceed about a mile. There are reasons for and against each of these plans. In the Deptford scheme the whole of the generating plant is concentrated in one locality, and the cost of working and supervision is thereby reduced. Moreover, the locality chosen has river frontage, and fuel can therefore be obtained at the cheapest possible rate. It has the further advantage of being sufficiently isolated to be practically free from the danger of causing annoyance to neighbors—a consideration of some importance. Legal proceedings against electric light companies, on the ground of annoyance to neighbors by reason of vibration, noise and smoke, are unfortunately not unknown in this and other countries, as shown by the examples of Paddington, Liverpool, Vienna, Paris and other places; and the Deptford works will, at any rate, be spared the annoyance of legal proceedings from ill-disposed neighbors. On the other hand, the selection of a site so far away from the districts where most of the profitable lighting can be done, has the disadvantage of either entailing a very heavy outlay for mains, or necessitating the adoption of a pressure which is largely in excess of anything hitherto attempted. Mr. Ferranti, the company's engineer, has chosen the latter alternative, and devised a type of main which may reasonably be expected to carry the standard pressure of 10,000 volts determined upon with safety; but until this expectation has been verified by actual experience, the necessity of employing so high a voltage is certainly one of the strongest reasons against the plan of concentrating all the power in one single centre. The Deptford scheme has also been criticised on other grounds, notably on account of the gigantic engines and dynamos which will there be used. One of the larger dynamos will supply some 200,000 lamps, and there are many electricians who hold that the risk involved is too great to compensate for any slight advantage in economy which may be expected from the increase in the size of the engines. The risk, of course, is that of the extinction of the whole of the 200,000 lamps, should anything go wrong with the dynamo or its two 5,000 h. p. engines. These are of the marine type, and in estimating the probability of an accident we are justified in looking to marine practice for precedents. What are the facts? Engines of that class are working in Atlantic liners at full power for six, seven or eight days without a moment's interruption, and a breakdown during the voyage is a very rare occurrence. Now, in electric lighting, these engines will not be worked at full power for more than a few hours daily, and during the rest of the time they will work at half or quarter load, or will stand idle. In planning the Deptford station the engineer has, in fact, provided for a complete set of spare machinery, so as to allow ample time for overhauling the engines and dynamos daily; and with the special apparatus designed to facilitate examination, there will be no danger of this being neglected. We may, therefore, take it that a breakdown from want of supervision and examination is almost an impossibility. If the engine of a steamer which must work at full power for a week, and can only be overhauled at long intervals, can be relied on, it is evident that an electric light engine, which can be overhauled daily, must at least be equally reliable. It might, however, be objected that, let the probability of a breakdown be as remote as you will, an accident is sure to happen now and then, and that even the engines of the Atlantic steamers are not exempt from this failing. This, no doubt, is true, and by analogy we must expect an occasional breakdown in electric light engines; but where a complete set of spare plant has been provided, the interruption to the lights can only last during the brief time required to throw the load from the disabled set of engines and dynamo to the reserve set. A piece of carefully designed machinery

does not break down without previous warning, and in most cases there will be sufficient time to start the reserve set before the working set must be stopped; so that the time occupied in the transfer of the load, that is, the time during which the lights will be out, need not occupy many seconds.

But even an extinction of light lasting only a few seconds is objectionable, and it is in this respect that the programme which the consulting engineers to the Metropolitan company have elaborated is specially attractive. Mr. Gordon, the company's engineer, does not believe in gigantic machines supplying current at 10,000 volts. He objects to the plan of putting too many eggs into one basket, and prefers to sub-divide the power into smaller units, even at the cost of greater complexity of the plant, and the consequent increase in the cost of supervision. According to the present arrangements, the capacity of each of the company's stations is to be about 500 kilo-watts, corresponding to the supply of ten thousand 16 c. p. lamps simultaneously alight, and the district is to be limited to a radius of about one mile from the station, the standard pressure being 1,000 volts. The consulting engineers are confident that it will be found possible not only to couple the dynamos at one station in parallel, but also the dynamos between the different stations, a feat which has been already performed in America, where two Westinghouse stations lying on opposite sides of a river are so connected, if the demand for current on one station exceeds its capacity. If these anticipations can be realized in everyday practice, the plan of sub-dividing the generating plant into comparatively small units will give absolute immunity from extinction of light, which might otherwise be brought about by a breakdown of an engine or dynamo; and in this respect the distribution will be as certain and continuous as in any of the low tension direct current Edison stations, which have now satisfactorily stood the test of years. The system has, however, also another advantage. When it is possible to run alternators in parallel, the number of machines kept simultaneously at work can be arranged to correspond to the output required; that is to say, no engine or dynamo need be worked very much under-loaded, and consequently the machinery at a station will, during the whole of the twenty-four hours, work with almost maximum efficiency.

The earning capacity of a central station is largely increased by its ability to sell power as well as light, and in this respect low tension direct current stations have hitherto possessed a decided advantage over any station supplying laternating currents. The Edison central stations in Boston, New York, Berlin and other large towns are doing a very profitable business in the supply of current for power purposes, and there can be little doubt that the above mentioned alternate current supply stations could do a very excellent business in the supply of power in many London districts, if only a suitable motor could be found. Two years ago this problem appeared to be an almost hopeless one, but at the present time, thanks principally to the investigations of Professor Ferraris, of Turin, we are within a measurable distance of its solution. We learn that a Swiss electrician in the early part of this year produced a serviceable motor, and that the apparatus devised by Mr. N. Tesla has, in the hands of the Westinghouse company, been developed into a practical machine. Messrs. Ganz & Co., of Budapest, are also busy with this problem, and have so far been successful as to produce a motor giving 66 per cent. efficiency. To judge from what has been accomplished in this direction within the short space of a year, we may confidently expect that the time is not far distant when the supply of motive power will, even with alternate current stations, be an important source of revenue. —*Industries.*

.... THE demonstration is now complete, that all the illuminating and power service of a city can be performed from one central station. Every consideration of economic advantage requires that it shall be done.—*A. R. Foote.*

DISCUSSION ON LIGHTNING CONDUCTORS AT THE BRITISH ASSOCIATION.[1]

(Continued from page 586, vol. vii.)

SIR WILLIAM THOMSON said that, with respect to the very marked difference between Professor Lodge and Mr. Preece, he might say that he considered Professor Lodge to be in the American stage with reference to the judging of the functions of inertia, and Mr. Preece to be rather in the English state, as described on Friday by Professor Ayrton. The functions of inertia were to prevent anything getting into motion, and when in motion, to keep it going; and both these functions are perpetually being performed in this electrical influence. He could not but think that if Professor Lodge continued his work, he would find the explanation of the discovery he had made, that iron wire affords an easier path in the circumstances that he has minutely defined than does copper. He hoped that Professor Lodge would continue his investigations, keeping the circumstances in all respects as similar as possible, comparing, for example, a thin iron wire with a thin wire of lead or brass of the same ohmic conductivity. Professor Lodge had done a good deal already, but a good deal more might be done by taking proper account of inertia, and of the other point that Professor Lodge had very properly accentuated—that the energy must be got quit of somehow and somewhere. If it were got rid of in the conductor, then there must not be energy enough to melt tne conductor. It was an interesting fact about the number of people in a row, where the extremes felt the discharge, while the intermediate ones did not. There was one very marked influence here, and that was want of perfect insulation; but there was another influence, also potent —self-induction. The influence of self-induction might be tried, and it would be a very interesting experiment. He thought they might try this same thing with as nearly as possible similar insulation with the same number of people spread out in a large circle. Then self-induction would be much more influential in causing the discharge not to keep through the line of the comparatively good conducting bodies, but to spread through the floor or ground under them. Take the case of persons ranged in a row and receiving an electric shock. If the row is zig-zag, then self-induction will not have the same tendency to cause the lightning discharge to leave the line of the best conductors, as it will have if the conducting bodies are placed in a wide circle. He believed the imperfect insulation of standing on the floor would be much more potent, and he should expect that those who were in the middle of the row would experience less of the shock in the case of standing in a wide circle than in the case of standing on similarly good conducting material in zig-zag rows. At all events, that was an experiment worth repeating. Mr. Preece had spoken of the impossibility of conceiving of the enormous augmentation of potential in these actions. Take the name "inertia," which Mr. Preece used; he fully agreed in the judiciousness of that term. Apply the word "inertia" to the steam hammer and the hydraulic ram. You begin with a comparatively gentle force, its weight bringing down the steam hammer, till it produces an exceedingly intense action at the blow. Take the hydraulic ram, the well-known analogue for getting up a high potential for self-induction in an electric circuit, and then, he thought, they would see that Professor Lodge's explanation of the phenomena he had brought before the meeting was altogether valid. He thought Mr. Preece was quite right in speaking of the multiplicity of flashes of lightning. He had given some unmistakable experimental and observational evidence of it which agreed very well with what he himself had noted. The first time that he distinctly remembered noticing it was in the summer of 1840, at Frankfort, where he had the pleasure of seeing a great many thunderstorms. He then remarked triple and quadruple flashes frequently, but at such short intervals of time that one could not but think that they were in some way connected, and yet at long enough intervals to allow him quite distinctly to see that they were not one flash, but several flashes. As Mr. Abercromby had said, it did not seem to be repetition of flash along one and the same course, but a succession of connected flashes. One flash seems to cause many others. Light had been spoken of—the light of one flash tending to produce another flash. It seemed that the very fine oscillations of light actually put the air into a condition which was more easily disrupted than air which is not agitated by light; but that would not account for the time interval between the different flashes which was spoken of by Mr. Preece, and which he himself had noticed repeatedly. He thought this might depend on the velocity of propagation of sound in the air. The first flash did produce certainly a tremendous disturbance in the air. He thought that they could not account for an electric flash through air otherwise than by supposing a crack in the air suddenly filling up and producing an exceedingly sharp elastic disturbance. It was quite possible that that elastic disturbance propagated at a rate nearly equal to the ordinary velocity of sound to another place where the air is in a state of high tension, ready to break down, caused it to break down. Thus it might be that one flash caused a considerable

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1. From *Industries*, November 23, 1888.

number of others at intervals of a quarter of a second, or a few quarter seconds, from its initiation. This was a thing that might be experimented upon.

Sir William Thomson then went on to suggest a plan whereby the simultaneity of flashes might be tested—proposing to use several cameras, each having before it a revolving shutter with a hole in it. These shutters were to be arranged so that, all revolving at the same speed, each was to be in advance of the next; so that no two cameras should be simultaneously open for exposure, and yet *one* plate should always be exposed during the whole period of duration of a flash. He then went on to discuss the question of the possibility of magnetization being effected by an oscillatory discharge. Reis had, he said, some time prior to 1853, experimented on the subject, and had magnetized steel needles by the discharge of a Leyden jar. He found that sometimes these needles were magnetized in the direction that would be expected from the direction of the main charge, and sometimes in the opposite direction. He (the speaker) believed, as Lord Rayleigh had stated, that experimenters had actually found differences of direction of magnetization in different individuals of a group or bundle of steel wires thus actuated, or rather thus exposed to this kind of magnetizing action. If they had a very powerful current going in one direction, followed by a current of half that strength going in the opposite direction, a current of a quarter the original strength going in the first direction, and so on, then they might expect the needle to be left magnetized by the current going in that one direction, corresponding to the last time that it had magnetizing force enough to magnetize or to reverse the magnetization of the needle. So that he thought by repeating Reis's old experiment with the same degree of electro-magnetic inertia in different successive cases, but with different degrees of ohmic resistance, and, therefore, different rates of extinction of the oscillation, probably a full investigation might be made. It was rather disturbing to find that a lightning rod had so little protecting power as, according to Dr. Lodge's experiments, it seemed to have. It was an exceedingly difficult thing to decide between iron and copper. He did not know whether Mr. Preece had any actual experimental evidence of the superiority of copper. Iron had one great advantage—it takes a great deal more heat to melt it. Take iron at a given price, and compare the cost of iron and copper; they could get four or five times as great a mass of iron as of copper for the same money. Take also the higher melting point of iron, and they would see that for the same expenditure upon the lightning conductor they would provide for the consumption of a great deal more energy within itself without destroying it by using iron than by using copper. Then the question of self-induction bearing on magnetization must be considered before they could say for certain that in all circumstances the iron lightning conductor is as safe as copper. One conclusion seems quite sure, viz., that a sheet iron house, a sheet iron roof, with sheet iron walls and sheet iron floor, is the very safest place that we can possibly be in, or that gunpowder can possibly be in, during a thunderstorm. Here he might say something which perhaps was absolutely wrong, but he would hazard it. The subject was full of pitfalls; but he would venture to say that the magnetizability of the iron seemed in this case rather to prevent the danger—to prevent the current coming into the inside rather than to facilitate its coming into the inside. He thought he might safely say this, that within an iron funnel—an iron vertical funnel, say—and within a copper vertical funnel, the interior would be protected in the case of the iron funnel by the magnetic susceptibility of the iron; whereas, in the interior of the copper funnel, there would be no protection from this cause, although in each case there would be a very potent protection from the conductivity of the metal. However, he thought, with what Professor Lodge had put before them, they knew quite enough about iron to say that an iron building would be as safe as safe could be—as safe as science can make it. He thought that was rather an important thing for powder magazines, and the rule should be to have no special lightning conductors at all; but iron roof, iron walls, iron floor—wooden boards over the floor naturally to prevent people setting fire to the gunpowder by walking over sheet iron—and a complete roofing of iron. This iron magazine might be placed on a dry granite rock, or it may be placed on wet ground; it may be placed on anything they pleased, it might be placed on a foundation under water; no matter what the surroundings are, the interior will be safe. He thought that was a somewhat important practical conclusion which might safely be drawn from consideration of these electrical oscillations and the experiments regarding them, and the trials for the mathematical theory of them—mathematical calculations of which they had heard so much.

Professor Rowland said that he was inclined to think that the arrangement of conductors in Professor Lodge's experiments did not fairly represent the circuit in the case of a lightning discharge. In Professor Lodge's experiments the whole of the circuit between the condensers was of iron and copper, whereas in the case of lightning the greater portion was of air, and this might materially alter the condition of things. Moreover, he was not disposed to say the spark would take place at the first moment. There might be considerable oscillation, and finally the air might be broken down. The oscillation might take place before the spark occurs, in which case the length of the spark might not be an index altogether of what they might call a temporary resistance of the conductor to the passage of the spark. The presence of iron might change the time of oscillation in the same way, so that it might give a different length of spark in that case from what it did in the copper. But he thought the fact should be remembered that in the case of lightning the greater proportion of the spark was in the air, which was a very bad conductor, and that therefore the passage of the lightning might not be oscillatory, but might be of the nature of a swing, in which case a solid conductor or a conductor of copper would probably be better than a tube of iron.

M. de Fonvielle said that, though a Frenchman, he took the liberty to disagree with Sir William Thomson, and to stand with Mr. Preece as an English conservative with regard to lightning conductors. He should advise the meeting to postpone its opinion until the completion of the Eiffel Tower in Paris—the most extraordinary lightning conductor ever constructed. Paris, he must say, was remarkably free from calamities from lightning. They had erected a sufficient number of lightning rods on the principles laid down by Mr. Preece to show that he must be going in the right direction.

Professor Forbes pointed out that the great question which had to be settled was between the lightning rod committee's recommendation of copper for the construction of conductors and Professor Lodge's assertion that their views were erroneous, and that if iron were not better for the purpose than was copper, it was certainly no worse. No one could fail to be impressed by the beauty and value of Dr. Lodge's experiments; yet he agreed with Professor Rowland in thinking that they were not quite conclusive on the point in question. The reason why he thought that they were not able fully to accept Dr. Lodge's experiments on the alternative path as sufficing to abolish copper rods for lightning conductors was this: In the experiment Professor Lodge had used two condensers, and he used a special case in which there were two sparks produced beside the alternative path. He had doubtless tried the experiment in a much simpler way, and more resembling the conditions which existed in the actual phenomenon. Supposing, instead of using those two condensers, they used the two poles of the Holtz machine; or; instead of having two pairs of knobs, suppose they used only one pair of knobs. They might connect the poles of the Holtz machine with a large battery of Leyden jars, and they would get all the better effect. The arrangement then was that they got a spark between the two knobs of the Holtz machine. They put an alternative path in the course of the spark, and then they tested to see at what distance a spark was just possible to take place. He wanted to ask Professor Lodge, when that experiment was being performed, whether an iron alternative path or a copper alternative path was best. The circumstances seemed to him to more resemble the circumstances in nature than the arrangement which he had described in his experiment, and he thought the conclusion was that the copper alternative path was the best, which would be an argument in favor of Mr. Preece's view.

Sir James Douglass said that his experience, extending over forty years, might be considered comforting to the committee. They had been following Faraday's advice entirely for the past fifty years for the protection of lighthouses, starting with the base of the metallic lantern and carrying down a copper bar (1¼in. by ⅜in., half round, in section) which was in communication with all interior metal work. The earth was obtained by a copper plate, 2ft. 6in. square and ¼in. thick, buried 15ft. distant from the tower, about 12 feet below the surface of the ground. At exposed stations at sea the bar was carried down to about 8ft. or 10ft. below low water mark, so as always to be immersed in the waves. During the forty years of his experience seven or eight accidents had occurred—none of a serious nature—and in all cases they had found a defect in the conductor. He thought that the rapidity with which iron conductors corrode would present a practical difficulty to their use in many situations, particularly in hot climates.

Mr. G. J. Symons, F.R.S., secretary to the Lightning Rod Committee, said that he had had nothing to do with the construction of lightning conductors, but that it had been his hobby all his life to inquire into any accidents from lightning of which he heard. The impression left upon his mind by these investigations agreed very well with what Sir James Douglass had said. He had no shadow of hesitation in saying that he believed that if people would put up conductors precisely according to the rules, and would fulfill all the conditions, they were absolutely safe. Professor Lodge's experiments (and he yielded to none in his appreciation of Professor Lodge as an experimenter) were only laboratory experiments. What they wanted was something on a far larger scale. He thought that a good deal of information might be gained from experimental conductors erected on some high hill. It seemed to him that a very serious responsibility attached to those who would allow it to go forth from that great association, that there was any uncertainty in the protection of the public buildings of the country. They had the experience of France, Germany, Austria, and the United States, as well as of England.

Tens of thousands of rods were erected in these countries, and it would be with considerable regret that he would hear it go forth from that room, simply on the strength of some laboratory experiments, that all that had been done was to be regarded as worse than useless. He agreed with Sir James Douglass with regard to the oxidation of iron rods. Even galvanized iron was not an everlasting material by any means. With respect to the area of protection, he knew that he was within the mark when he said that hundreds of cases had been investigated, and that there were not, as regards the area of protection laid down by the conference, more than two instances in which anything had been struck within this area, and even these cases were a little doubtful. Churches were continually being struck; but then they had not properly constructed conductors. The conference had advised that the conductor should end in a blunt point, and about six inches below this there was to be a ring carrying sharp needle points—the latter to disperse the electricity and act as a preventive, the former to receive the flash if it did occur.

(To be continued.)

CORRESPONDENCE.

NEW YORK AND VICINITY.

Meetings of the Board of Electrical Control.—Developments of Rapid Transit Schemes.—New Suburban Electric Road.—The New York Central Tunnel to be Lighted by Incandescent Lamps.—The "Times" upon the Fourth Avenue Storage Battery Cars.—Penitentiary Wardens Instructed in the Use of Electric Apparatus for Execution of Criminals.—Theatres Adopting the Alternate Current for Lighting.—The Use of Electric Appliances on Naval Vessels.—Startling Explosion of Gas in Subway Man-holes at Madison Square.

THE meeting of the Board of Electrical Control, held on March 5th, was enlivened by the presentation of charges by Commissioner Gibbens against the United States Illuminating Co. on the ground that that company was not acting in good faith. A spirited war of words ensued between the commissioner and Mr. Eugene T. Lynch, president of the Illuminating company. The company succeeded in securing forty-five days in which to test the subways, "at the end of which time," the Mayor remarked, "that if the poles are not removed I will order them taken down by the Bureau of Encumbrances."

The Mayor thought he detected a scheme to prevent the removal of poles of the Western Union Co., the police department having wires strung upon that company's poles, and measures were taken to secure an appropriation to put the city's wires in the subways, and at a subsequent meeting the board was informed that $15,000 had been set aside for that purpose.

At the meeting of the Board of Electrical Control, held on March 19th, the Mayor stated that it was useless to read the long list of applications to string wires, as under no circumstances would they be granted. As a consequence of such repeated refusal to consider such applications a large number of enterprises are at a standstill. The board ordered the construction of subways as follows:—

West side of Sixth ave., from Fourteenth to Eighteenth sts., and east side from Fourteenth to Twenty-fourth sts; south side of Fourteenth st., from First to Sixth aves.; Twenty-ninth st., from First to Fifth aves.: Murray st., from Broadway to College place; Centre st., from Worth to Grand st.; Houston st., from Crosby st. to First ave.; Thirty-eighth st., from First to Lexington aves.; Seventy-ninth st., from First to Park aves., and Lexington ave., from Sixty-fifth to Seventy-ninth sts.

The efforts being made to secure rapid transit have naturally been opposed by the stockholders of the elevated railroads, who seem to have counted upon ultimately securing additional privileges. Mr. Jay Gould, president of the Manhattan Elevated Railway Co., writes to Mayor Grant under date of March 7th, offering this solution of the problem:—

"Let this company build a third track on Third and Ninth avenues and increase the terminal facilities at Battery place and Brooklyn Bridge." Such concessions would be violently opposed, as only affording a temporary makeshift and injuring property more than ever. It is believed that Mayor Grant's plan is to purchase a strip of ground on the east side in the centre of the blocks and erect a stone structure wide enough for four tracks from Battery place to the Harlem River.

The Port Chester, White Plains and Tarrytown Railway Co. will be run by electric motors and the overhead system. This line will run through a thickly populated residence district, and may ultimately be extended farther up the river.

The Fourth avenue tunnel of the New York Central Railroad, which has been described as an "ugly, smoky, dark and disagreeable cavern," is to be lighted by incandescent lights.

"The New York *Times*, in a recent editorial referring to the Fourth avenue storage battery cars, says:—"The electric motor cars, now run for a short time in the evening, are a revelation to New Yorkers of what comfort, and even luxury, is possible in a mode of travel that has heretofore been a continual nuisance."

The legislature having made the necessary appropriation for the execution of criminals by electricity, the wardens of the three state prisons have been receiving instructions from Mr. Harold P. Brown at Menlo Park, N. J.

The first theatre in this city to install the alternating current is Proctor's new theatre on Twenty-third street. The installation was made by the Manhattan Electric Light Co., which operates the Slattery induction system. The system has given such satisfaction that it is said three other theatres contemplate adopting it.

A naval officer during the trial of the new steamer "Vesuvius" remarked "that the countless devices by which electricity is made applicable aboard ship are simply marvelous. Small electric motors are used about the decks and below for hoisting and other purposes, and all parts of the ship are brilliantly lighted without the usual attendant heat and exposed flame. The difference in ventilation alone calls for unceasing praise. Search lights are now provided of sufficient power to light up the water a radius of nearly a mile, and so detecting the approach of any object." The "Chicago" is fitted with a complete duplicate plant, and it is expected that all new steamers will be fitted out with duplicate electrical apparatus.

Three explosions in the subways occurred almost simultaneously just before noon on March 25th, and within 200 feet of the entrance of the Fifth Avenue Hotel at Madison square. The people in the streets and square were thoroughly frightened. and many narrow escapes from flying cobblestones were reported, but no serious injuries were done, excepting, possibly, to one lady who was struck on the knee by a cobblestone and was taken home in a carriage in a fainting condition.

The Board of Electrical Control immediately issued the following announcement:—

The explosion was the result of the leakage into the subways of quantities of gas from the mains of companies operating in the neighborhood. It was not directly or indirectly brought about by any underground electrical current, inasmuch as no electrical current was passing through the subways at the time of the explosion. It would have occurred in a closed cellar or any other receptacle into which like kinds of gas could penetrate and combine with air and other gases under similar circumstances. The man-holes at which the explosion took place are frequently examined and ventilated. There are five gas companies operating near by, and it is impossible to tell as yet which one or more should be held responsible for the leak or leaks occasioning the explosion. The following letter has been sent by order of the Board of Electrical Control to each of the gas companies:—

"Your attention is called to the fact that, owing to a leak or leaks from gas pipes in the vicinity, three of the subway man-holes at Fifth avenue and Twenty-third street were exploded this morning, causing serious inconvenience and seriously endangering lives of citizens.

"Your company has mains and connections in this neighborhood, as well as elsewhere in the city. You are respectfully requested to take immediate steps to prevent any further escape of gas into electrical subways, if such escape comes from your pipes in this or any other locality."

Inasmuch as no loss of life has resulted from this explosion, it is, perhaps, fortunate that it occurred before the electric current had been transmitted over the wires placed in the subways, for if any of the conductors in the subways at the time of the explosion had been in operation, a new and serious question as to the practicability of operating electrical conductors underground would immediately have been raised.

The Board of Electrical Control will take measures to exclude all kinds of gases from the subways in the future as in the past with even more vigilance than hitherto; but the exclusion of the gas from the subways has the effect of driving it into the basements of buildings, and the real remedy is in the hands of the gas companies, inasmuch as upon them the responsibility of keeping gas within its proper channels and the prevention of casualties and illnesses caused by its escape must ultimately rest.

NEW YORK, March 22, 1889.

PHILADELPHIA.

The Philadelphia Electric Trust a Profitable Venture.—New Electric Light Companies Projected.—A Bill to Abolish all Overhead Wires in Cities before September next Introduced in the State Senate; Comments Upon It.—The Bell Telephone Company of Philadelphia; its New Building and its Subway Work.—Electric Light Service at Pottstown, Pa.

THOSE gentlemen who hold the preferred stock of the Philadelphia Electrical Trust are said to have made a pretty good thing out of it. There are 5,000 shares of a par value of $100 each, and they are now quoted at about $145. They are guaranteed 8 per cent. The common stock, which amounts to $3,000,000, is quoted at from 33 to 35, and earns about two per cent. The Electric Trust has a controlling interest in all the local arc light companies, and carefully sees that no one encroaches on another's territory. Thomas Dolan, the president of the trust; John Lowber Welsh, R. H. C. Hill, William G. Warden, George I. McKelway and William Wood are some of the gentlemen who are credited with having added to their incomes by their investments in the trust.

There is a movement on foot among South street business men to run an independent electric light plant, and boycott the companies who now furnish the lighting in that region. Already the movement has taken an organized form under the name of the "South Street Merchants' Association," with the following officers: President, W. H. Embick; secretary, Joseph Gregson; treasurer, James Gallagher, and directors, Andrew Marshall, Joseph Hollard and W. H. Carslake.

Every effort is being made to keep the project a secret until the plans are perfected and the association in shape to meet the opposition the members expect to meet from the electric light companies, to whom it will prove a dangerous rival, owing to the cutting in rates which is proposed. The association will be a stock company, and to those holding stock lights will be furnished at 20 cents per night, and to the outside public at 40 cents, the last price being a large reduction from the terms of present companies. Further, to secure the sanction of the city councils in the scheme, it is proposed to place a light in the centre of each square for a considerable distance down Gray's Ferry road, for which the city will be charged nothing.

The merchants of the northeastern section of the city also have the electric light fever, and an ordinance granting permission to the Merchants' Electric Light Co. to open streets, and lay and maintain underground conduits and wires for electric lighting was considered at a meeting of the electrical committee in select council chamber recently. The ordinance authorizes the company to lay its conduits and maintain its wires under a number of streets in the northeastern section of the city, and contains the proviso that no street be broken until the plans of the company shall have been approved by the board of highway supervisors. The ordinance was directed to be reported to councils with a favorable recommendation.

In the Senate at Harrisburg, on February 28th, Mr. Harlan presented a bill prohibiting all suspended electric wires in cities of over 30,000 population after August, 1889.

"It is a physical impossibility," said Chief Walker, of the electrical bureau, when asked his opinion of Senator Harlan's bill for putting electric wires underground. "Why it would take five years to carry out the provisions of the bill," said he. "Every one knows that I am a strong advocate of underground wires, but it will take time, and no man who lived in a large city would propose a bill of that kind. There are 12,000 miles of overhead wires strung within the city limits, There are already 600 miles of wires underground and more being placed. But to talk of burying 12,000 miles of wire in six months is absurd, and it will cost $5,000,000 to do it, too.

"The tendency of electricians is to put all wires underground, and the best interests of the city demand it. The removal of danger to life is, of course, the first consideration, and the danger of spreading fires would be greatly lessened if every overhead wire was buried out of sight. There's nothing scares a fireman like a live wire hanging over his head. Among the electric light companies the incandescent concerns are all willing to bury their wires; but some of the arc light companies say that the underground system is in its infancy, and not far enough advanced for their purpose."

Dr. Plush, general manager of the Bell Telephone Company, said that his company was placing wires underground as fast as possible, but that Senator Harlan's bill was impracticable, inasmuch as the laying of conduits alone for all their wires would occupy at least a year.

The Bell Telephone Company, of Philadelphia, has awarded the contract for the erection of a headquarters and central office building at Nos. 406 and 408 Market street. The new building will be handsome, and in keeping with the many massive structures that have been built in the business section during the past few years. The company will spend $75,000 for a switch-board in the new building.

In a few weeks the telephone company will continue work on the subway on Market street, which is designed to hold all the wires that are now overhead on that and adjacent streets. The subway extends from Front to Eleventh street, and will be continued out Market street to the Schuylkill river. It will make a detour around the City Hall via Thirteenth, Arch and Fifteenth streets. Most of the work will probably be completed within the present year. The plan is to have small conduits extending from Market street on every alternate street, so that wires may be carried through them to a tall pole in the centre of a block and then distributed to the buildings within the block. This work is designed to bury all the wires between the two rivers and Vine and South streets, and will entail a cost of $1,000,000. The Western Union Company's wires will also be carried in the same subway and conduits.

The borough council at Pottstown, Pa., have agreed to accept the electric light service now offered at $125 per arc light per year. The lights are of nominal 2,000 candle-power, and are to burn all night.

PHILADELPHIA, March 18, 1889.

.... WE must not forget that the province of the electrical engineer touches upon that of the civil engineer.—*Sir William Thomson,*

.... IN no other way can a city promote industry among its citizens as surely as it can by securing for the largest possible number the use of light and power, under conditions favorable to their requirements.—*A. R. Foote.*

BOSTON.

Activity in Electrical Affairs.—Output of Telephones.—Favorable News Advance the Price of Bell Stock.—Connecticut Legislates Against Eavesdropping by Telephone.—Annual Statement of the Central and South American Telegraph Company.—Boston Aldermen Take Up Electric Lighting.—An Exhibition of Electrical Welding.—High Prices for Thomson-Houston Shares.—Overhead and Underground Wires—The Hearing at the State House on Street Railway Conductors.

THE electrical pot continues to boil in this vicinity; the introduction of electric railways and the transmission of electricity for motive power of all kinds stirs up things wonderfully. The telephone people complain that the strong currents interfere with their service. Last month the telephone company cut the wires of the Woburn Electric Light Company, between Fowle street and Winchester. The companies have disagreed for some time regarding their respective rights, and the electric light company placed wires on the poles after being requested not to do so.

The statement of the output of telephones by the American Bell Company for the month ended Feb. 20 is as follows:—

	1889.	1888.	
February—			
Gross	4,231	3,972	Inc. 259
Returned	2.212	2,088	Inc. 124
Net	2,019	1,884	Inc. 135
Dec. 21 to Feb. 20.			
Gross	8,078	8,002	Inc. 76
Returned	4,129	3,760	Inc. 369
Net	3,949	4,242	Dec. 293

The repeal of the "Indiana law" last month helped to send the American Bell stock up to 229; of course the recent legal victories contributed to send the stock up, as did also the report that the long-delayed microphone patent was soon to be issued to Berliner.

A bill was passed by the Connecticut Senate the first of this month, aimed at a new class of "Peeping Toms." In the Trowbridge-Ingersoll scandal case in New Haven, some months ago, important evidence was obtained by tapping a telephone wire and listening to conversations between the lady and her admirer. While this was indirectly in the interest of detecting wrong-doing, the telephone company was indignant, and asked for the bill which passed. It imposes a fine not to exceed $500 on any person who shall make a connection by wire or otherwise with any telegraph or telephone wire, not owned or leased to such person, for the purpose of obtaining information or listening to the transmission of messages.

The annual statement of the Central and South American Telegraph Company for the year ending Dec. 31, 1888, shows: Gross revenue, $538,729; operating expenses and expenditures for ordinary repairs, $133,261; dividends on $4,006,600 capital stock, $270,445; surplus, $135,022; total surplus Dec. 31, 1888, $331,596, including $201,001, the surplus of previous years. The time required to transmit messages between Buenos Ayres and London, "via Galveston," is now less than forty minutes. The report says that a duplicate cable between Galveston, Texas, and Coatzacoalcos, Mexico, was completed on Feb. 19, and that its cost will be provided for out of the surplus earnings of the company.

The committee of the board of aldermen have returned from a trip to Chicago, to inspect the underground wire system. They went at the invitation of the Boston Electric Company, who paid their expenses. On the 4th, as a result of their trip, the aldermen passed the following order:

That the committee on public buildings consider and report as to the desirability of placing in the basement of the City Hall an electric light plant of sufficient capacity to light the entire City Hall, Court House and the building occupied by the Register of Deeds.

In response to an invitation from the Thomson Electric Welding Company, a large party assembled at the station of the Malden Electric Works, on the evening of the 4th inst., to witness the process of welding by electricity. Among those present were representatives of the Boston and local press, members of the Malden City government, and gentlemen actively interested in the development of electrical industries. The full capacity of the apparatus was shown by the union of two pieces of iron two inches in diameter, the time required being a little more than a minute. The power employed is directly proportionate to the size of the pieces to be welded, and, by increasing the horse-power, much heavier work is possible. The variety of uses to which this method of welding may be applied is almost endless, and it is destined in the near future to be of the greatest value to the metal interests of the country. On the evening of the 7th inst. another exhibition was given.

The Thomson-Houston stocks have appreciated rapidly within a few weeks. This week Thomson-Houston Electric Company's shares were quoted at 275 bid, 300 asked; Electric Welding at 400.

At the State House hearings, overhead wires and electric street railways are having a shaking up.

The hearings in regard to the dangers from overhead electric wires on street railways have been very interesting. It is signifi-

cant that the opposition to the overhead method comes from gentlemen interested in the storage system. But when men come forward and tell of taking the strongest alternating current, without serious result, the fears of the people of dangers from the comparatively feeble currents employed by the street railways are quieted to a considerable extent.

In the mass of testimony submitted it is very hard to extract or boil down. But some very interesting statements have been made; none more so than the communication of Mr. F. L. Pope.

In regard to the physiological effects of high potential currents Professor Elihu Thomson said that the amount of current which a man is capable of receiving depends upon his power of resistance. In Lynn, his company is welding iron bars with a current of 50,000 amperes, but you can put your tongue between the ends of the wires and not feel the current.

The destruction of human life, he said, usually came from a wire of 2,500 or 3,000 volts; it was the opinion of electricians generally that the danger point is above 1,000 volts.

William McQuesten, in charge of the West End electric railway system, said he had taken two shocks, in one case the voltage being 1,200. He never knew of destruction to human life from the overhead wire. He said that the West End's wires were protected by fusible joints. It was only an instant, just as the wire fell, that a shock was possible. In regard to other wires falling on the road's wires, he said the latter were protected by guard wires, which made the falling of telephone or telegraph wires across the road's wires next to impossible. Further testimony was submitted by men who had received shocks to show that the wires are not fatally dangerous.

Mayor Russell appeared for the Cambridge Electric Light Company, and several of the officers and employés of the company testified. One of the employés had taken a shock from a 500-light alternating current dynamo of 1,000 volts.

Mr. C. J. H. Woodbury, of the Massachusetts Mutual Factory Insurance Company, was called by Mr. Cummings, and testified that no higher rates were demanded for factories in which electric lights are used.

Mayor Russell, of Cambridge, spoke of the absence of danger in the overhead wires, and said that if the voltage of these wires is limited, the same limitation must apply to the light and power wires, and thus would a blow be struck at the immense industries which are being developed by electricity.

On storage batteries for street cars, at the State House hearing, Mr. S. A. B. Abbott presented numerous affidavits as to the practicability of the Julien storage system, and Mr. Wm. Bracken testified to the same effect. He said that Mr. Whitney would have adopted the system on the West End Railway but for the fact that the storage company declined to agree to light the cars. Mr. Abbott said that he had shown that all the dangers incident to the overhead system might be obviated by the storage system, and he claimed that it could be obviated also by the conduit system. At all events, it was due to the public that all other methods should be properly tested before resorting to the overhead system. There should be a limitation of the voltage to 500 volts, and a provision that there shall be a registry of the voltage kept. He asked further that the use of the alternating current be prohibited.

Mr. Hyde said that the only opposition to the overhead wires came from a storage battery company of New York, which had a system that no railway company was willing to adopt, and the storage company has the assurance to come here and ask the State of Massachusetts to legislate in its behalf. The West End Railway Company had spent $15,000 in experiments on the storage system, and it was not a success; when it was demonstrated to be practicable and efficient, he should be glad to adopt it. The West End company were forced to resort to the overhead system, and no accident had occurred on the road. It was the most efficient, economic and best adapted for street railway cars that has been found thus far. He could not say what progress might not be made in the future. He had no objection in having a clause in the bill permitting the use of the storage system. Give all a chance, he said, but let us have none of their dog-in-the-manger policy.

Mr. Bracken, of the Julien company, then went on to speak of the advantages of the storage system. He was subsequently questioned by Mr. Hyde, his answers bringing out the facts that it required six or seven hours to charge a battery; that the batteries in a car weighed 3,400 pounds; that they contained sufficient energy to last six hours, and that it costs two cents per car mile to run cars in New York. To the committee Mr. Bracken said that the company had sold none of its cars, but was now ready to do so.

As to conduits, Mr. Bracken submitted documentary evidence in support of his proposition that both alternating and continuous currents are dangerous to life when carried overhead. In regard to the alleged failure of the conduit in Boston, Mr. Bracken said the conduit system was doing a thousand times better than the overhead system was doing a year ago.

Professor Thomson said he understood the conduit system was not a success. He predicted that it would not be, on account of the leakage, which the peculiar conditions made it impossible to overcome. He knew of no conduit system in existence which he would trust. He would, however, gladly welcome a conduit system which was feasible. He would prefer a conduit for city work. He did not like to see the wires any more than anybody else. He was not in love with them. In out-of-town work there can be no question that the overhead system will always be the most economical as well as the most practicable. In reply to Mayor Russell, of Cambridge, Professor Thomson said that, in case of restrictive legislation compelling the wires to be placed underground, the whole enterprise would be defeated and the use of electricity abandoned. The difference in the cost of the two systems must be considerable. The overhead line can be put in for $2,000 or $3,000 a mile; it was impossible to say how much the conduit system would cost, but it would be many thousands, and probably so high as to be prohibitive.

BOSTON, March 16, 1889.

CHICAGO.

The Chicago Electric Club; Dr. De Bausset on Aerial Navigation; Mr. Cutter on Handling Electric Light Circuits: Interesting Experiments.—Professor Barrett on Electric Subways.—Electric Train Lighting on the Atchison, Topeka & Santa Fe R. R.—The Chicago Medico-Legal Society Discusses Electrical Execution.—Electric Motors Suggested for Drawbridges on the Chicago River.—Marriage of Mr. John H. Reed, of the Mather Electric Co.—Electric Light Employees Nearly Killed by Suffocation in a Conduit Manhole.—The Leonard & Izard Co. Organized to Succeed the Firm of Leonard & Izard.

AT the meeting of the Chicago Electric Club, March 4th, Dr. A. De Bausset spoke on the subject of aerial navigation. He described in detail the air ship which he proposes to build whenever he obtains financial encouragement from the government. His plan is as has been stated a number of times, is to exhaust the air from a cigar-shaped steel cylinder 600 feet long and 120 feet wide. According to his calculation enough air will be displaced so that his ship will float in the atmosphere. A car will be attached to the cylinder in which machinery, 200 passengers and 50 tons of freight will be carried. He proposes to use a wheel similar to a propeller wheel and to employ storage batteries and a gas engine for motive power. Dr. De Bausset is confident that his scheme is practicable. He has figured out every detail so that he can state the exact material of which each portion of his cylinder and car will be composed. He believes that Congress will soon give him money enough to make the first ship, the cost of which will be about $150,000.

At the Club meeting, March 18, George Cutter gave a practical talk on suggestions for handling electric light circuits. A large number of members was present. The subject was treated by Mr. Cutter in a popular way, and was illustrated by several experiments of an interesting character. Mr. Cutter showed the heating effects of the electric current; its effect upon the magnetic needle, the effect of the magnet on the voltaic arc were among the experiments.

Professor J. P. Barrett, city electrician of Chicago, is a firm believer in the underground system, as he indicated during the convention of the National Electric Light Association. He said recently, "The subway commission in New York seems thoroughly in earnest and I am not surprised, for the conduits which have been constructed in the city seem to be models. The people demand the burial of wires and it will have to come to that. The underground system in Chicago has been successful and it will also prove economical."

The Atchison, Topeka & Santa Fe Railroad Co. proposes to extend its system of electric lighting to all its trains running out of Chicago. Heretofore only vestibuled trains running to Kansas City have been equipped with electric light apparatus. On the local trains only storage batteries will be used. The coaches will be run into the yard and the batteries charged without removing a cell from its position under the car. The through trains will continue to be equipped as at present, with Brotherhood engine and storage batteries.

The Chicago Medico-Legal Society has been discussing the question of electric executions. The New York plan did not meet with the approval of the physicians. To put it bluntly, they considered that hanging was humane enough for the criminals who were punished for capital crimes. One doctor stated his preference for poisoning the criminal, in accordance with the Grecian custom.

The Chicago *Herald* has been urging the employment of electric motors for operating the drawbridges in Chicago. In an editorial on this subject it says:—

> With steam, the weight of the structure is very largely increased by the boilers and water, as well as other cumbersome appliances. There must now be a steam engine and boiler for each bridge. In case electricity were used it could be generated at some central point and carried by wires to the various bridges. The bridges could, with only the additional weight of an electric motor, be made much lighter than they are at present. This would be a substantial economy in the cost of construction, which would lighten materially the expense of bridge building. In truth, the time is not far distant when the electric motor will be an economical substitute for the great majority of engines now operated by steam

John H. Reed, manager of the Chicago office of the Mather Electric Co., and Miss Lillian A. Smith, of New York, were married March 3, in Chicago.

Two employés of the Chicago Arc Light & Power Co., had a narrow escape from suffocation by gas in a man-hole recently. They were rescued by a policeman.

The Leonard & Izard Co., of Chicago, has been formed to assume the business heretofore conducted by the firm of Leonard & Izard. The object of the corporation is stated to be "to deal in engines, electrical appliances and supplies of all kinds, to build electric railways and to furnish experts in electrical engineering work." The incorporators are H. Ward Leonard, E. M. Izard and H. K. Tenney.

CHICAGO, March 21, 1889.

MONTREAL.

The Annulment of the Edison Incandescent Electric Lamp Patent.—Complicated Relations of Telegraph Companies.—Business of the Royal Electric Co.—Electric Lighting Notes.—The Underground Wire Question Arising in Canada.

READERS of THE ELECTRICAL ENGINEER will have seen the announcement of the annulment of the Edison lamp patent in Canada, through a decision of the Commissioners of Patents at Ottawa. The effect of this decision will be far reaching respecting electric lighting in Canada, the commissioner's decision giving a color of doubt as to the value of many patents held in Canada.

Early in the year 1888, the Edison company brought suit in the Superior Court, at Montreal, against the Royal Electric Co., for infringement of Edison patent No. 10,654, usually known as the "Edison carbon filament patent." This patent was considered a controlling one. The Royal company in defense brought a counter suit before the Commissioner of Patents praying for the annulling of the Edison patent.

The Commissioner in his decision[1] discusses the case fully on the merits and in its relation to precedents. The judgment has attracted widespread public notice, not only in the Dominion but in the United States, where its effect upon the Edison patent for the same invention will, it is thought, be disastrous to the Edison interests.

That public sentiment is awake to the need of a reform in the patents' act, giving a more liberal scope to Canadian patents, will be seen by the following from a contemporary:

> We do not desire, at present, to criticise the judgment of Mr. Pope in the Edison case, but we cannot refrain from expressing our opinion that the time has now come when a change should be effected in the Patent Law with respect to the Patent Office decisions. It does not appear to be reasonable that in matters of such grave importance as these patent cases usually are, one judge—however able—should be the final arbiter of great and valuable interests. An appeal should certainly be allowed to the Supreme Court of Canada. Without wishing to be understood as expressing the slightest doubt as to the impartiality or ability of the present occupant of the position, it does undoubtedly shock one's sense of justice that the determination of questions of intricacy and magnitude should be left to the irrevocable and final judgment of any single judicial officer. The interests of patentees should be as carefully guarded as any other class, and we venture to suggest to the government the amendment of the patent act in the direction indicated.

There has been a telegraph squabble on the tapis for some time, resulting from the lease of the Montreal Telegraph Co. by the Great Northwest Co. an ally of the Western Union.

About 1880, there were only the Montreal Telegraph Co. and Canada Mutual Telegraph Co. operating in Canada; the latter, the Western Union connection. Both companies were running at a loss. The Western Union Co., acquired the charter of a company termed the Great Northwest Telegraph Co., and began active preparations for a competitive system as against the Montreal Telegraph Co. Advances were about this time made to the Montreal Telegraph Co. looking toward a permanent lease of that company's property and franchises. The lease was signed in 1881, and is for a term of 99 years. The Western Union are sureties, guaranteeing the payment to the Montreal Telegraph Co. a dividend of eight per cent. during the continuance of the lease. There is a proviso allowing the Great Northwest Telegraph Co. to release themselves by a lapse of 30 days in the monthly payments. This they are unwilling to do as heavy investments have been made by them in construction and extensions. They have accordingly proposed to the stockholders of the Montreal Telegraph stock to reduce the dividend to six per cent., with a covert threat to allow the lease to lapse. This not having the desired effect, they now sue the Montreal Telegraph Co. for breach of contract in not maintaining rights of way ceded to the Great Northwest Co. over various lines of railroad, throughout the Dominion. The Canadian Pacific Railroad Co. during 1882 and the years subsequent, leased the above-mentioned roads acquiring the right therewith to erect telegraph lines on the right-of-way thus obtained, and commenced a competitive business on what should be the right-of-way of the Great Northwest Co.

Now comes the rumor on the streets, that the Canadian Pacific have expressed a willingness to amalgamate their telegraph system with that of the Great Northwest Co. If such should become the case at a later day, the telegraph field here will then be entirely in the hands of the Western Union's ally, the Great Northwest.

The Royal Electric Co. are very much pushed in their factory, and are running up to eleven o'clock at night.

1. An abstract of the decision is printed in our Legal Notes.

They have recently wired the Standard building for 150 lamps and the Bank of British North America for 25 lamps. The Cyclorama is being supplied with 17 arcs. The Craig people have placed a 300-light series system station at St. Jerome, and are lighting that village. The electric light situation in Toronto has resulted in a petition to the Ontario government and to the Dominion government praying for power to enable the Ontario government to make it compulsory that all electric wires throughout that province shall be placed underground. This bill comes up in the Dominion parliament to-morrow. Such a bill would seriously cripple the electrical industries in Ontario, and it is believed no such bill will pass. Meantime, the electric light companies at Toronto are awaiting the issue of this bill, until the city council can enable them to proceed either overhead or underground. The Toronto council appointed a committee who recently visited the states to inspect underground work there with a view to placing wires underground in Toronto. As yet nothing has been done.

MONTREAL, March 19, 1889.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall street, New York city.*

THE BATE CASE—ARE YOU RIGHT?

[104.]—It is usually pretty safe to be, in matters concerning patents, on the same side of the fence with the editorial articles of the ELECTRICAL ENGINEER.

A close observation of the decision in the Bate case recently, does not, however, in the humble opinion of the writer warrant the doctrine editorially stated in the March number, "that foreign patents terminating prematurely, by the failure of the patentee to pay taxes or stamp duties, will adversely affect a previously issued United States patent for the same thing."

No tribunal in the world is so careful to abstain from crossing a bridge before reaching it as is the United States Supreme Court. This court even in the Bate case declined to express an opinion upon a point, which though argued, was not properly in the case.

It hardly seems fair, therefore, to read into the Bate decision an opinion upon a point which did not even remotely enter into the case.

The untimely expiration of a foreign patent issued for a full term, because of the non-payment of a periodical tax is, so it seems to me, on quite a different footing from the expiration of a short term patent which might have been but was not renewed. When a patent is applied for in foreign countries, it is usually under the control of the patentee, and he may elect for himself (if he first takes out his foreign patent), whether he will take one for a long or short term; that is, of course, in countries where this can be done. But generally the patent once issued passes to an assignee, who may, if he finds it unprofitable, let it fall by the non-payment of a periodical tax. It would, to say the least, appear inequitable, if a patentee in the United States should be made to suffer for the action of a licensee. Moreover, the action of the Supreme Court is in the line of aiding the patentee, and such a construction as was placed upon its decision by the ELECTRICAL ENGINEER would be adverse clearly to the spirit embodied in the said decision.

OBSERVER.

LITERATURE.

The Telephone. BY WILLIAM HENRY PREECE, F. R. S. and JULIUS MAIER, PH. D. London: Whittaker & Co. New York: D. Van Nostrand, 1889. Crown 8vo., cloth, pp. xvi. 498. Price, $4.00.

THIS new volume of The Specialists' Series is a praiseworthy attempt to meet a long felt want in the literature of telephony, and is evidently the product of no small amount of conscientious labor. The plan is comprehensive and in general satisfactory; but we regret to find errors of a sort hardly to be expected in a work for which Mr. Preece assumes the chief responsibility. It is, in fact, mostly compiled from other books and from electrical journals, and should at least have been revised by some one practically familiar with the subject. The title is ambitious, but the book does not fully supply the need of a hand-book of telephony.

The preface states that little heed has been paid to priority, but this disclaimer is hardly a sufficient excuse for describing the ordinary American Bell telephone as "the Bell Receiver of the

Swiss Telephone Administration." The statement that "by continuous improvements and careful workmanship this instrument is said to have been brought to a state of perfection which is not surpassed by any other Bell receiver now in use," is not a little amusing, in view of the fact that the description is that of the Bell hand telephone exactly as made in America and put on the market about 10 years ago.

One of the older forms of the well-known standard switchboard appears under the guise of the "Swiss Commutator," while the present form of the same instrument is credited to Mr. Charles Williams, Jr., instead of to the Western Electric Co., from whom the Swiss appear to have got their first model about eight years ago—if we may judge from the pattern illustrated.

Curiously enough, too, the description of the standard switchboard is jumbled up with that of the Williams' plug switch.

The ordinary American pole-changer is also shown as a part of the "Swiss System," but is not called by its accepted name.

The form of Edison transmitter shown and described is not the one which was adopted in practice, but an earlier model, of which very few were made.

Under receivers and transmitters a number of unimportant and rather rubbishy instruments are shown which have scarcely ever been seen outside of electrical journals, while some forms which have come into pretty wide use are entirely omitted; no mention being made, for instance, of the American "long-distance" transmitter, or of the Pony Crown telephone, or of the present receiver of the German Telegraph Administration. Nor is Hunnings (called Hunning in the book) recognized as the original inventor of the granulated carbon transmitter. He is classed along with his followers—Hipp, Berthon, Berliner, etc. We are inclined to consider the Hunnings's transmitter as perhaps the most important European contribution yet made to the development of telephony.

A series of tests of induction coils, to ascertain the most efficient form, is cited and discussed at length, without a reference to the omission of elements so essential as the size of core used, and the amount of battery power applied; omissions which render those tests almost worthless.

The treatment of the magneto is inadequate; insulators are neglected; and house-top fixtures are not even mentioned. We should have been glad to see illustrations of some of the graceful iron fixtures used in continental cities, which long ago replaced the clumsy wooden ones, such as are still so abundant in America.

The bronze line wire mentioned (0.8 mm., or 32 mils), seems to us absurdly small. We have heard of telephone companies renouncing the use of 1.25 mm. wire (50 mils), as too small, and adopting heavier wire. The discussion of air lines, however, is much more satisfactory than that of cables, which is very weak. We take leave to differ with the view that the first requisites of aerial cables are lightness and tensile strength, and the American telephone engineer, accustomed to the common use of 50 and 100 wire aerial cables, will be somewhat surprised to be told, on the authority of the technical chief of the British telegraphs, that the practical limit of the number of wires in an aerial cable is 27. What would Mr. Preece say, we wonder, to the 150 wire aerial cables at St. Louis, or the 200 wire cables at Chicago?

The statement that "underground work has hitherto been tabooed" in America, is rather wide of the mark, the fact being, of course, that American cities have five or ten times more underground telephone cable than all Europe! The question of retardation is not even mentioned. The shielding of the conductors with lead or tin-foil as a remedy for induction between wires, which is apparently recommended, does not meet with favor in this country.

The British post office occupies a good deal of space in the book, considering its rather unimportant position in telephony. The description of the "Post Office System" is the first chapter under telephone exchanges. The "system" appears to be entirely official as to its origin. The switch-board especially is truly official in its clumsiness, and we do not wonder that the P. O. subscribers—officially called "renters"—are even willing to throw themselves into the hands of that grasping monopoly, the telephone company, in their anxiety to escape from the too affectionate embrace of a paternal government. The range of the official mind may be inferred from the mention of exchanges "of from 100 to 300 subscribers" as "medium sized."

Although the book contains many errors, and is therefore unfit to place in the hands of the inexperienced, there is in it also much useful information, well arranged and agreeably presented. It is so good that it ought to be a great deal better without much difficulty, and we trust that the sins both of omission and of commission will be atoned for in a later edition; when we hope that the statistics and general information as to the state of the art may be brought down nearer the date of publication. The most satisfactory portions are, perhaps, the introductory chapters and the description of the multiple switch-board. The illustrations are atrocious, with a few exceptions, one being the frontispiece—an excellent picture, by a photographic process, of the Manchester Telephone Exchange, recently fitted with new switchboards.

We would suggest for the mutual benefit of both publisher and reader, that the book would probably have a greater success in this country if offered at a more reasonable price. The American telephonist who pays $4 for it is likely to conclude that he has paid about $2 too much—and to say so.

Notes.

R. VON FISCHER-TREUENFELD'S Index of Publications on Methods of Communication in the Field and on Torpedo Warfare, recently published by H. Alabaster, Gatehouse & Co., London, will be found useful by military readers and by students of modern methods in warfare. The index, as would be expected, deals mainly with the various military applications of electricity, but includes references to military railways, communication by carrier pigeons, carrier dogs and velocipedes; and to such topics as military ballooning, audible signaling and cryptography. More than 700 titles are given of books, pamphlets and articles in technical journals, covering English, German, French, Italian and Spanish publications. They are classified under twenty-nine headings. The principal subjects are fairly summarized by the title of the book:—Communication (telegraphy, telephony, signaling); Torpedo Warfare (explosives, exploders, torpedoes, military mining, etc.). A few topics scarcely less important, but not coming under either of the above heads, are included, such as electric lighting and light apparatus, ballistic apparatus and range finders.

WE have had on our table for some time, Three Kingdoms: A Hand-book of The Agassiz Association, written by President Ballard and issued by The Writers' Publishing Company, New York Its dedication "to the memory of Louis Agassiz, in the hope of leading many to follow in his footsteps", is well fitted to the purpose of the book, viz., to make known the organization, scope and methods of the Agassiz Association and to make its work attractive to all who have leisure or inclination to join it for the observation and study of natural objects systematically. The association's scheme should be particularly attractive to the young. Boys and girls may under its guidance acquire habits of close observation, and systematic classification of familiar or unfamiliar objects in the natural world of the utmost value; to say nothing of the great pleasure and satisfaction attending such work. It is gratifying to read that in seven years more than 15,000 students had been aided in their work and over 1,200 local societies had been formed. Three Kingdoms is a handsome little volume. It gives full information about forming local societies, plans of work for societies or individuals, and some preliminary rudimentary instruction in the study of nature. It is to be hoped that the book will fall into the hands of the many bright girls and boys who would find in it an incentive to useful and delightful work.

RECENT PUBLICATIONS.

Economic Value of Electric Light and Power. By A. R. Foote. Cincinnati, 1889: *Robert Clarke & Co.* 12mo., cloth, 191 pp. Price, $1.00.

Fourth Annual Report of the Board of Gas Commissioners of the Commonwealth of Massachusetts. Boston, January, 1889: *Wright & Potter Printing Co.*, State Printers. 8vo., paper. 193 pp.

Grand Concours Internationale des Sciences et de l'Industrie, Bruxelles, 1888. Notice sur le Concours 47. Electricité. Bruxelles, 1888, 143 pp.

Transactions of the American Institute of Electrical Engineers, Vol. v. [Meetings from September 20, 1887 to October 9, 1888.] New York: *Published by the Institute.* 8vo., cloth, 435 pp, and appendix—Index of Current Electrical Literature—pp. xiv.; xv.; xvi.; xxi.; xxii.; xix.; xviii.; xvi.; xviii.; xiii.;

CATALOGUES AND PAMPHLETS RECEIVED.

The Automatic Switch Co., Baltimore, Md., issue a pamphlet circular describing the Whittingham Automatic Switch, and offering it to the trade. The switch is designed for use in starting and stopping constant potential motors. By a clever arrangement of lever and a dash-pot, one motion on the part of an attendant serves to put the field magnets of a motor into circuit and to set in operation the gradual admission of the current through the armature automatically. The circular contains a good description of the device handsomely illustrated.

We have received a new circular and price list from the Simplex Electrical Co., Boston, containing fresh information as to the use of their insulated wires, tapes and tree insulators. Besides the usual wire tables the circular contains many testimonials to the high quality of the simplex insulation.

We have recently received the new circular of the "Elgin" Telephone & Electrical Supply Co., Elgin, Ill. This company has been for several years engaged in manufacturing and supplying mechanical telephones, and has carried that mode of communication to a very serviceable degree of utility. They have also for some time carried on a business in general electrical supplies, telegraph instruments, batteries, house service apparatus, etc. Their list fills a 48 page pamphlet.

.... IF all the obstructions that have ever been placed in the way of any step of progress were rolled into one, and placed in the way of the advent of electric light and power, it would be impotent to very much hinder the progress of the inevitable.—*A. R. Foote.*

NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

February and March Meetings.

MEETING OF FEBRUARY 12th, 1889.

The meeting was held at the College of the City of New York.

In the absence of the president, Mr. C. O. Mailloux was chosen chairman for the evening.

The chairman, after appropriate introductory remarks, called upon Lieutenant F. Jarvis Patten, who then, according to the programme of the evening, read a paper on "A New System of Multiplex Telegraphy." (See ELECTRICAL ENGINEER, March, 1889, page 85.)

DISCUSSION.

The Chairman—It is rather to be regretted that our eminent telegraphists are not present this evening. It certainly is a very interesting paper. For a long time, telegraph authorities have been of opinion that the day of mono-telegraphic work is past; that the cost of using the telegraph circuit and maintaining it is so great that we must be able to utilize it, and multiply its use by making it answer for more messages than one at the same time. In bringing before us this interesting paper, Lieutenant Patten has unquestionably given us something which represents the beginning of the future, and you certainly should not lose the opportunity of giving it a thorough discussion.

Mr. P. B. Delany—I have to compliment Lieutenant Patten on the very clear and entertaining discourse he has given on a very interesting subject, and a subject in which I have had some experience. I would ask Lieutenant Patten, how many contacts to the line he proposes to give for each Morse circuit, so as to make the circuit sufficiently continuous for the manipulation of the average Morse operator. I didn't catch clearly the number of pulsations per second that he proposed to apply to each branch circuit with his distributors.

Lieutenant Patten—The question cannot yet be answered with all the definiteness I would like to give it; but, in general terms, I would say the number of segments given to each operator necessarily depends upon his speed. I would simply say that we have four contacts to a line. We have made a sounder work with clear action from an artificial line, of course, at the rate of 30 words a minute. There are two things which determine the number of contacts to be given to any operator in the circumference of a distributor; one is the speed at which the trailer is driven, and the other is the amount of time that the trailer rests in contact with the segment. Four contacts give a good reliable result; that would give about 1200 pulsations per minute.

Mr. Delany—The object of my enquiry was to ascertain the number of contacts that could be given to each operator, and at the same time afford the necessary duration of contact between the distributing trailer and each segment, and enable you to transmit currents over a line of a considerable resistance.

Lieutenant Patten—That is a refinement of the subject which can only be determined by prolonged experiment. I would say that with a few thousand ohms resistance we could get lower than $\frac{1}{400}$ or $\frac{1}{500}$ part of a second from a single contact.

Mr. Delany—You say that with 1200 contacts a minute, you get a sufficiently continuous circuit?

Lieutenant Patten—So far as our experiments have indicated, which are on an artificial line.

Mr. R. W. Pope—It is my impression that Mr. Delany's experience does not quite coincide with that of Lieutenant Patten, in regard to that contact, and I would like to hear what Mr. Delany's experience has been as to the number of contacts per second necessary to permit of fast Morse manipulation on long wires.

Mr. Delany—My experience would lead me to believe, in a general way, that on a circuit of, say, 100 miles, from New York to Philadelphia, for instance, with perhaps 1200 to 1500 ohms resistance, and an iron wire of a capacity, probably, of 1½ or 2 microfarads, that about 500 impulses per second can be transmitted over such a line and received on segments corresponding in position in the circle on a circuit table, provided the trailers and the distributor are in synchronism, and allowing a slight moment of time for the retardation of the circuit. If the retardation amounts to $\frac{1}{500}$ part of a second then the current sent at one segment in a particular position in the circuit will be transferred to the segment next in the direction of the revolving trailer. After each impulse has been sent into the line, the charge that is in the line delays the next impulse that goes into the line, and delivers it in a segment still further removed at the receiving end. I have found that in the operation of Morse circuits, what we call good Morse circuits, it requires at least 35 or 36 impulses per second to make a smooth circuit, so that the operator manipulating the key, as is frequently done, at the rate of 12 to 15 times in a second, may transmit to the full measure of his ability, or say, 40 words a minute.

On such circuits with that number of contacts in a second, I have seen more than 40 words transmitted for a considerable period of time continuously, say, for half an hour, over circuits about as I have described. In order to do that it requires a circuit that varies not more than $\frac{1}{1000}$ part of a second. If there is variation in excess of that, the currents become so weak that the relays would go out of adjustment, or it would be very sensibly felt at the relays at the receiving station.

Lieutenant Patten—Mr. Delany has remarked upon a feature that it might be of interest to mention in connection with this system. I might have put it into the paper; but, as I have said, I did not care to go particularly into detail. There is an essential difference between the system as shown here, and any system that is founded on the isochronous motion of different moving parts at different stations. For instance, if the instruments were driven by an isochronous machine and were absolutely synchronous, the two trailers would be at the same angle of position at the same instant; and if an electric impulse were sent over the line, and it took any time to reach the other end of the circuit, it is evident that the trailer would have left the position where it was when the impulse started. In a system of this character where synchronism is maintained—variable—you might describe it as transmitted synchronism; the trailer is just as much behind the initial one at the receiving station in time as it requires the current to reverse the line. These refinements are somewhat delicate, but if there is such a distinction, it is evident that we have more chance of getting the current out in a system that is varying than in one that is isochronous. I merely bring this point out to show the difference between synchronism independently maintained and that maintained by the circuit; I would like to ask Mr. Delany what he used for the circuit he describes working the old Morse instrument; I would like to ask what E. M. F. he used?

Mr. Delany—We used about 75 volts on the circuit. I mark the distinction that Lieutenant Patten wished to draw as to synchronism that is maintained by machines that are not isochronous in their movements, and that such synchronism in his system, is maintained by transmitted impulses. I would say that the synchronism with which I have had experience is also maintained entirely by transmitted impulses, that is, the synchronism is not maintained in any way by the isochronous method, independent of the two machines. One machine is corrected in its movement by impulses transmitted from the other end of the line, the receiving machine is corrected by the transmitting machine, and vice versa. The impulses are sent in opposite directions at different periods of the rotation of the trailer, so that if the current is sent over segment No. 1, we will say, at station X, and if it takes the time represented by the distance from No. 1 to No. 2 segment, to reach the receiving end and the correcting impulses which keep the instruments in synchronism maintain that relation and position of the trailer. We have found it necessary in practice to maintain the instrument in synchronism on corresponding segments, where it was necessary or desirable to telegraph in opposite directions simultaneously. Because you will readily understand that if segments at each end of the line are connected to operator A, and one operator is sending to the other, and the instruments are in synchronism and get the time of the impulses over the line as represented by the time of the trailer from one segment to the other; it will readily be understood that if A be sending to B, and the instruments are in synchronism for that condition, if B should turn around and send to A, A would not receive the impulses that were sent to him. Consequently, we have two synchronizing and corresponding segments if we wish to work in opposite directions simultaneously. So that you find the segment representing the time on the line at the receiving end connecting the operator to that segment and holding the instrument in that relation, the time of the impulse from each operator being the same. But where the time on the line is such as to make the transfer more than the margin allowed (than the variations of the instruments on the face of corresponding segments), you cannot work in opposite directions simultaneously.

Mr. C. J. Kintner—I desire to call attention to the fact, which Lieutenant Patten appears to have overlooked in his description of his apparatus, that it is, so far as I am aware, the first apparatus by which isochronous movement is effected by the apparatus itself. We all know the old Casselli system, which is perhaps the first isochronous telegraph with which we are familiar, in which the isochronous movement is brought about by the movement of a pendulum. In Mr. Delany's system, with which we are all familiar, that is done by the harmonic principle. In Lieutenant Patten's system, it depends upon the peculiar phases of the alternating current generator, and an alternating current motor of the same capacity or same efficiency, so that the two motors in all positions are dependent on the two phases in those positions. It was my good fortune last summer to make a somewhat extended set of tests and experiments upon Lieutenant Patten's apparatus, as to its efficiency and as to the isochronism of the apparatus.

I found that the machines ran uniformly in synchronism; and during the experiments, a very interesting feature came out. We were using six sets of keys at each end of the line, and I tested with all the keys closed at each end, one key closed, and successive keys, and various numbers of keys, closed to see whether there was absolute synchronism. I discovered that when key No. 1 at section No. 1 was closed at each end, there was a faint response—if closed on section No. 1, there was a faint response on section No. 2. I called Lieutenant Patten's attention to it, for the reason that I could not understand it. At last upon close examination of the trailers, I found that they were set slightly at an angle, so that as the trailers passed off section 1 they were slightly passed on to section No. 2, so that we had a response on the other section, which was an absolute proof of the synchronism of these two sections. I desire to call attention to the fact that the apparatus is capable of operation, as the Lieutenant has advised me, with an alternating current, in which it is possible, as I understand, to transmit messages over longer lines, because that with an alternating current he is able to discharge the line more rapidly.

Mr. F. B. Crocker—Lieutenant Patten has spoken several times about variable synchronisms. It is perfectly correct; but it sounds rather startling to the ordinary hearer, because the idea naturally is that synchronism is constant, and he makes the distinction between synchronism and isochronism. There is a distinction, of course, but he did not explain it very fully. Synchronism means that the two instruments revolve together whether fast or slow, whereas isochronism means that they revolve together at a certain speed. With a variable synchronism he may start off two instruments revolving together at 100 revolutions, and he may work up the speed of both at the same time to 1000 revolutions, and they will run synchronously just the same as the two driving wheels of a locomotive. In that way we have a variable synchronism. I think the confusion that might arise on this distinction is worth pointing out.

Lieutenant Patten—Mr. Crocker's distinction is quite correct. I had intended to bring it out; but perhaps did not do so quite clearly enough, but the distinction is in further illustration of my paper, and I thank him. In working the instruments, we try to drive them at a rate as uniform as possible. I brought out this idea of variable synchronism as a distinguishing feature of the system, not as one that would necessarily be used to a large extent. If machines are running at a good speed, a uniform 100 or 200 revolutions per minute, they are isochronous machines, and, of course, synchronous also. But if their speed is changed, they are no longer isochronous for the time being, they are simply synchronous.

Mr. Davidson—Mr. Kintner has suggested that the Delany system was based on a harmonic principle. I do not so understand it. As I understand it, no question of harmonics is involved. The circuit breaker is employed to control the rotation of the motor at either end of the line. That circuit breaker, it is true, may be a fork, it may be a rotating wheel; that is entirely immaterial. There is no question of harmony about it. As the circuit breaker makes and breaks the circuit of the local wheel at the end of the line, what is after all a small electric motor is rotated; that is, the passage of the pole on the disc or armature in front of a magnet coincides with the break in the circuit; that produces the rotation. Now the character of the impulse sent from one station to another merely modifies the circuit breaker; it slows it or accelerates it, and the two instruments are thus tied together: I do not understand that it is at all analogous to a harmonic telegraph.

Mr. Kintner—I accept the suggestion; I simply wanted to convey the idea that in Mr. Delany's system, like Casselli's, the synchronism was maintained by an extraneous apparatus.

The Chairman—We have with us this evening a gentleman who knows something of multiplex telegraphy in Europe, our friend, Mr. Abdank-Abakanowicz.

Mr. Abdank stated that he had never made a special study of telegraphy, but he had examined with great interest the synchronous devices of Lieutenant Patten, and was impressed especially with the performance of the motors running in synchronism.

Mr. Delany—When Mr. Davidson referred to the making and breaking apparatus, I was going to make the description a little more clear by stating that it was an automatic circuit breaker originally, a tuning fork in connection with what is known as the phonic wheel; that is perhaps where Mr. Kintner inadvertently got his idea of harmony. My synchronous and my multiplex telegraphs are based primarily on the very ingenious contrivances of Mr. Paul La Cour, his automatic circuit breaker in connection with a phonic wheel.

The Chairman—There is a great deal of interest to be said on this subject, but as the time is passing away, we shall have to take up the consideration of the next topic, which is the notes on Mr. Acheson's paper, by Messrs. Jo. Stanford Brown and C. T. Child.

Mr. Brown then read the notes as follows :—

LIGHTNING ARRESTERS AND THE PHOTOGRAPHIC STUDY OF SELF-INDUCTION.

Notes on Mr. E. G. Acheson's paper,[1] *by Jos. Stanford Brown and Chas. T. Child.*

Having been requested upon very short notice to reopen the discussion on the highly interesting paper on "Lightning Arresters and the Photographic Study of Self-Induction" presented at the Institute meeting held January 8, the following hasty notes and queries are with diffidence offered for consideration. Truth alone is sought, and it is a matter of regret if any criticism should even tend to disparage the worthy endeavors of one who has so fearlessly grappled a problem fraught with such interest alike to both theorist and practical electrician.

After careful reading it would seem as if the subject might be approached with advantage from more than one standpoint, and that even somewhat different conclusions were deducible simply by rearrangement of the experimental data. We have given a submarine or subterranean cable, to each end of which at its junction with the main line a lightning arrester is connected in the most approved manner, figure 1, to determine why, in spite

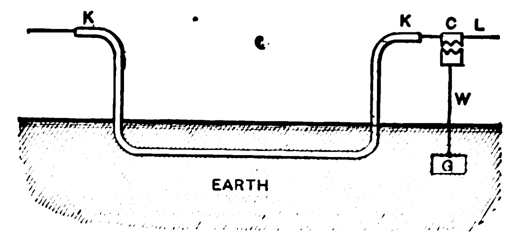

FIG 1.

of these precautions, the cable is not infrequently punctured when an "electrical discharge" enters the overhead system.

For experimental purposes this has been reproduced in miniature, as shown in figures 2, *2a*, *2b* and *2c*, by the line L entering

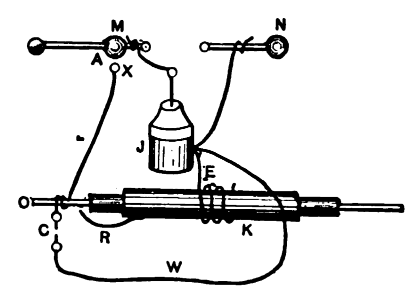

FIG. 2.

A and C constant.
B and W variable.
Capacity of J—.0025 m. f.
" " M and N not given.

the cable K at the point P, to which point is attached the lightning arrester C grounded through the wire W. The "electrical discharge" arises from the Leyden jar J, charged from the Holtz machine M N, and strikes the line at A. The outside of J will represent the earth, to which the ground wire W and the "earthing" of the cable, represented by E, "twisted a single turn"

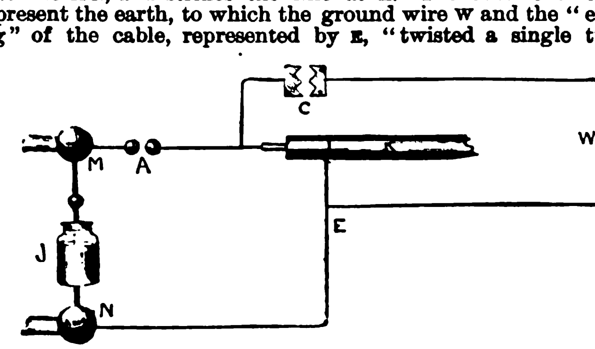

FIG. 2 *a*.

Fig. 2 redrawn.
Case of a cable protected by a lightning arrester.

(*Western Electrician*, iv., 47) about the cable, is connected. Is it not possible, then, to throw figure 2 of the previous paper into the form figure *2a* for the purpose of drawing attention more directly to the relation of the circuits involved? The discharge, or momentary current, from the jar J entering at A traverses the

1. See ELECTRICAL ENGINEER, February, 1889, page 47.

line L to the point P, where two paths are offered; one, through the lightning arrester C to earth E; a second, in practice, by puncturing the cable insulation. C now being made but a fraction of the insulation thickness, and W a short, thick copper wire, it was found that the cable was still frequently punctured at times

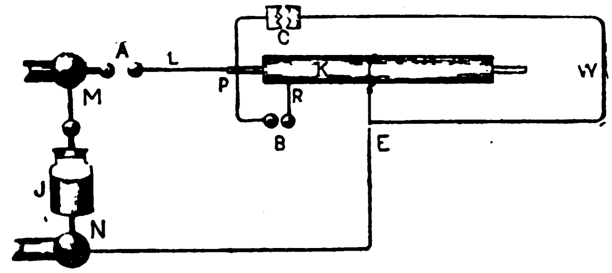

FIG. 2 *b*.

when a spark appeared at C, and that the length of W appeared to enter the effect equally with the space variation of C. *No part of the effect*, it will be noted, *is attributed to the action of the cable as a condenser.*

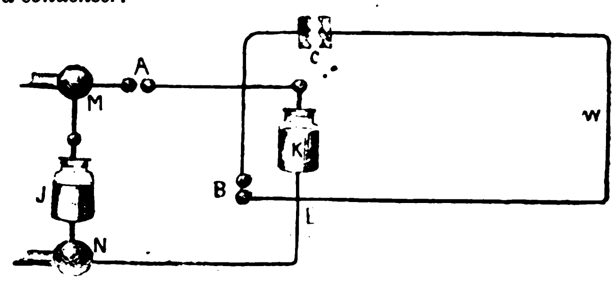

FIG. 2 *c*.

Equivalent to Fig. 2, with cable replaced by a condenser.

The problem is now changed to that shown in figures 3 and 3*a*, presenting a divided circuit with the lightning arrester at a constant distance of .02 inch and the earth wire W long compared with that connecting the variable B space with the same earth point. May not this arrangement of split circuit with an air space in each branch be looked upon as the general case for which Dr. Lodge's "alternative path" represents the condition of making

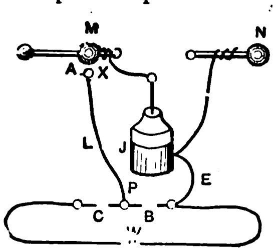

FIG. 3.

one of the air spaces zero? What then is the relative efficiency of changing the length of W and the distance of the C points *to prevent* a spark at B which represents the puncturing of the cable insulation, providing the B points are held equivalent to the long length of cable wire at any point at which puncturing may occur?

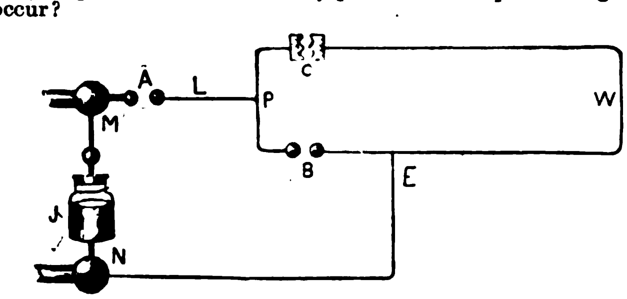

FIG. 3 *a*.

Fig. 3 redrawn.
A constant = 0.286."
C " = 0.020."
B variable.
W, of copper, .062" diameter, with variable length.

To decide this with A and C fixed at .286 and .02 inch respectively, B was varied with W to keep the spark ratio of B to A constant at one to 10. Then removing C (*i. e.* for C equal zero) the operation was repeated, and a comparison of these results is shown in the curve, plate A. Instead of this procedure, should not B have been made non-sparking for C and A fixed, and W varied until a spark was got at B, and then W left constant for variations of C up to a point where B would spark?

That with the connections of figure 4 and W equal 20 feet a spark should pass at B of over ⅓ inch in length might perhaps have been expected from Dr. Lodge's results (London *Electrician*,

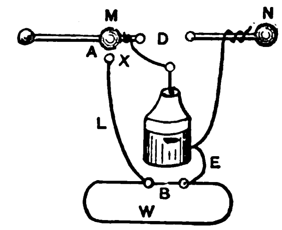

FIG 4.

xxi., 815), shown here in figure 4*b*, when there is an alternative path in which the self-induction of W (Lodge's L° loop) comes into play. True, figure 4 is not an "alternative path" of necessity, for the B points may be moved out of the sparking distance.

W is now supposed "electrified" by the charge across A. The "inverse extra current" of making simply cuts from the charging current; but the "direct extra current" of breaking, *i. e.*, charging impulse cessation, acts as its continuation but at a higher potential (Ganot, 7th edition, 776). This extra current then is running toward E and would naturally be supposed to equalize on the same path as the current generating it. It might, therefore, be expected to dissipate on reaching earth; the circuit is, how-

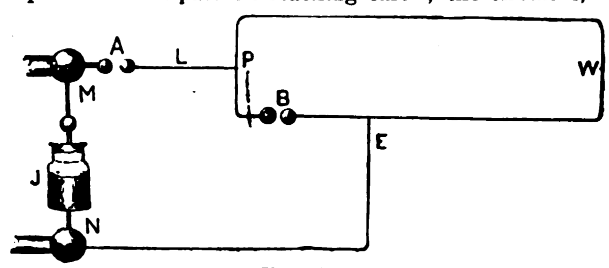

FIG. 4 *a*.

Fig. 4 redrawn.
A constant = 0.286."
B " = 0.333."
C removed.
W = 20 feet of copper wire, .052" diameter.

ever, claimed to close itself through P W E B, or, more clearly, around the closed circle of the L° loop, figure 4*b*.

It would be of interest to some in this connection to know how it was ascertained that the instantaneous time duration of the extra current is shorter than that of the charging current; for if this be assumed, because of the known higher electromotive force of the former, the argument would seem to be in a circle.

On the assumption that the extra current dissipates through B, and not in the earth, it is argued that shortening W would tend to decrease this tendency to puncture the cable. To test this we have B equal the insulation thickness, C and W removed, and we get figure 2*b* if the C W circuit be supposed omitted. "With this

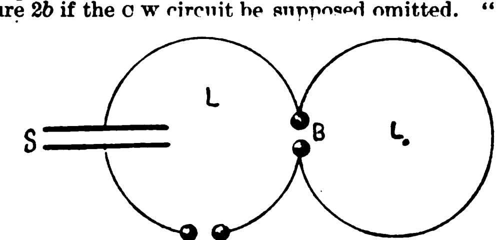

FIG. 4 *b*.

Cut of Dr. Lodge's Fig. 2, London *Electrician* (vol. xxi, page 815), showing alternative path.

arrangement it was not found possible to puncture the cable." May not this be regarded simply as a safety short circuit for our cable considered as a Leyden jar? And what is this but a working case of a cable effectually protected by a lightning arrester B? While the electrostatic capacity of a "short piece of cable" may be negligible compared with that of 20 feet of No. 16 B. & S. wire, it is perhaps doubtful if the capacity of a commercial cable could be so regarded in comparison with that of the ground wire from the lightning arrester.

It is not altogether plain how the direct extra current is an effect of Faraday's electro-tonic state when Faraday says (*Researches*, i., 16): "This state is altogether the effect of induction exerted, and ceases as soon as the inducing force is removed. And Jaquez ("Dictionaire d'Electricité et de Magnetisme," 1887,

p. 188) defines it as "the state of the conductor during the interval of time which separates the appearance and disappearance of an induction current." Maxwell, by the way ["Electricity and Magnetism" (2d Ed.), ii., 174], calls it "the fundamental quantity in the theory of electro-magnetism." Would it not be possible to regard it as an electro-magnetic potential stored in the wire ready to show itself as direct extra current? With the citations quoted above, how can this electro-tonic state exist *before* the electrifying current is discharged into the circuit?

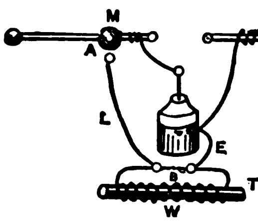

FIG. 5.

T=0.25" diameter.

Figures 5, 5*a*, 6 and 6*a* illustrate effects of different kinds of work introduced into the circuit. For references see Fleming's "Short Lectures to Electrical Artisans," pp. 44, 45, and Ganot, 7 Ed., 776; Maxwell, "Electricity and Magnetism," 2d Ed., ii., 211; Dove, Poggendorff's *Annalen*, vol. xlix., 1840, etc.

The methods used in the photographic part of the investigation would seem to cast some doubt on the results claimed. The effects noted deal chiefly with the prolongation or diminution of the current wave of the jar discharge by the secohmic resistance cut into the circuit. Might not a large element of uncertainty be introduced in the plates by the different degrees of illuminating power possessed by the sparks and by the irradiation of the plate?

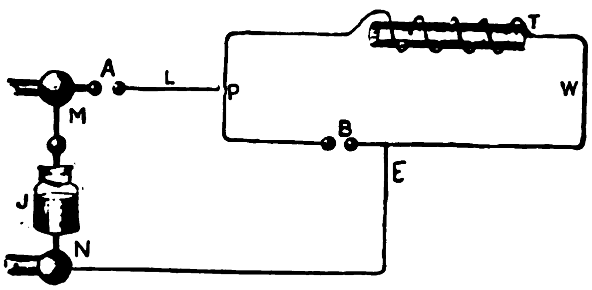

FIG. 5 *a*.

Fig. 5 redrawn.

In the cases when the discharges are through 76 and 20 feet inches of the same wire, respectively, hardly any difference appears in the spark. Is it not possible that the illuminating power of the quick bright spark through the short wire was so much greater than that of the necessarily more extended and consequently fainter spark through the long wire as to make the effect practically the same?

In the experiment in which two spark intervals are included in the circuit, as against one, formerly, it was found that the spark was materially lengthened. This might be expected considering the practically infinite resistance of the second air space which is introduced. The spark length too was found inversely

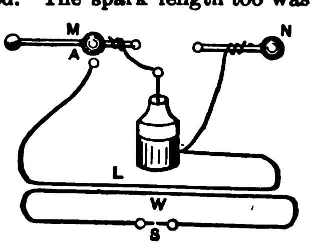

FIG. 6.

Length of parallel portions of circuits, 35"; distance separating them, 0.052."

proportional to any form of work introduced in the ground wire circuit. Possibly the photography of spark durations is not altogether the best method of measuring them. It is not yet by any means certain that a sensitive plate is equally affected by small equal time intervals at the beginning and end of the exposure, nor is it improbable that with sharp-edged holes moving at an extremely high velocity some diffraction phenomena might intervene that would introduce serious errors in the photograph. It is, besides, very difficult to measure the faint trails of light left by the spark. On the negative they are practically invisible, and in the prints their extreme delicacy and the fact that they fade away into the surrounding blackness without any sharp line of demarcation renders them almost impossible of measurement. On these grounds the measured spark distances of the first part of the article are probably more trustworthy as a basis for theory than the photographic results of the second part.

Returning to our original problem, why may not the cable, acting as a condenser, puncture itself in discharging, it having

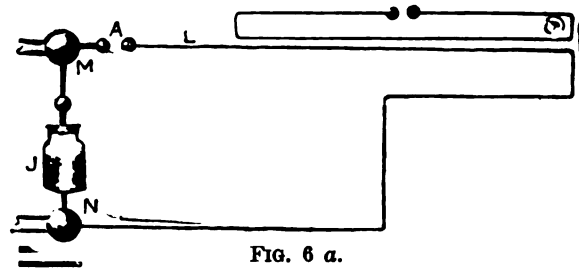

FIG. 6 *a*.

Fig. 6 redrawn.

been charged by the current from A, figure 2*c*, which, meeting the lightning arrester, backs up its potential until able to strike across and thus to ground? This discharge occurs simultaneously with the spark at C.

If a wave of current be pictured passing along a linear conductor, it would probably appear something like figure 7, its front

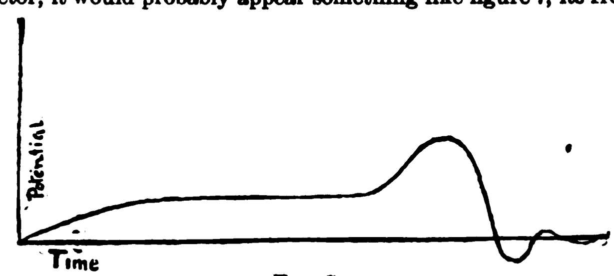

FIG. 7.

Form of current wave.

lengthened out by the self-induction effect of the cable, while the tension in the rear part is raised by the direct extra current. This high potential wave crest moves along the cable until, finding a weak spot in the insulation, it discharges rather than keeps up its strength with the impeding current ahead of it.

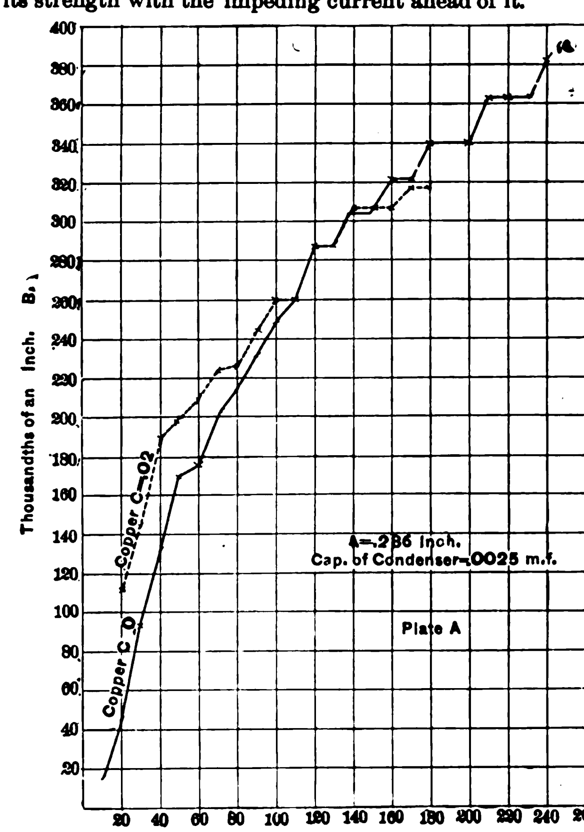

PLATE A.

We hope to be able to present at some future meeting the results of certain experiments delayed so far by pressure of professional engagements.

The Chairman—Gentlemen, these interesting notes are now before you for discussion. It is to be regretted that Mr. Acheson is not here, because he is so familiar with the subject; however, as the authors promise us a paper at a future meeting, we feel quite certain from the foretaste that they now give us that the paper will be of great interest. The subject-matter of these notes is one that is now receiving a great deal of attention all over the world, particularly in England, on account of its great bearing upon transmission through cables, and more remotely on the effect it has in all underground work. Consequently, it is a matter which is well worthy of study by electrical engineers in general, as well as of specialists.

The Secretary—I may say that these notes were prepared with a view of presenting the points for future criticism; for that reason the paper was presented in its present form, to be elaborated at some future time.

Mr. Abdank will be pleased to give some information with regard to an electrical headquarters, which it is proposed to establish at the Paris Exposition. He has spoken to me about it, and asked me to present the matter, but I would like to have him explain it himself, I think he would do it better.

Mr. Abdank—We have this year an Exposition in Paris, as you know, in which there will be a special section devoted to electricity, and I am in charge of that section for the United States. I have collected a very good exhibit, and I suggested having in the American section, headquarters for the electricians of the United States. We will have there a collection of all the electrical papers published in the United States and the books published here, and then we will have a special attendant there, who will have in charge a register, where the members of the electrical societies can come and find necessary information; and I would suggest that the society here give us for the Exposition a collection of the proceedings for its headquarters, and a book wherein the members of the society arriving in Paris may inscribe their names. We shall have a special box for the reception of letters addressed to members, and any member intending to visit the Exposition can have his letters delivered there, by simply having them addressed to "Paris Exposition, American Section, *Box Electricale*." Our office boy will put all the letters in order, and we will distribute them to the members arriving in Paris.

The Secretary—The council, as you are probably aware, has arranged to supply a set of proceedings to the Exposition, and I presume they will act on Mr. Abdank's suggestion and furnish a register for the recording of names.

The Chairman—I have no doubt that the subject will be taken up in due course by the council, and that our secretary here, with his usual eye to everything relating to the welfare of the society, will see that the matter is attended to in the proper manner.

MEETING OF MARCH 12.

The March meeting was held in Professor Doremus's lecture room in the College of the City of New York, Mr. T. Commerford Martin, vice-president, in the chair.

Having called the meeting to order, the chairman said :—

In the absence of our secretary, Mr. Ralph W. Pope, who is unfortunately detained by sickness in his family, it devolves upon me to introduce the business of the evening. I have much pleasure in announcing as the subject of the evening, "The Efficiency of Methods of Artificial Illumination," the paper upon which will be read by our fellow member, Professor E. L. Nichols, of Cornell University, and I have now the pleasant duty of calling upon the Professor for his paper.

Professor Nichols then read his paper, on "The Efficiency of Methods of Artificial Illumination." (See page 158.)

DISCUSSION.

The Chairman—Gentlemen, I am sure that you must have heard with the greatest pleasure the very able paper of Professor Nichols, and I think that it invites us to a very full and free discussion. We have with us this evening a number of gentlemen who are interested in this subject, both from a scientific and commercial point of view, and some of them have had practical experience in the inadequacy of the candle-power test to express the light-giving capacity of a lamp, and they have had some difficulty in convincing city councils and other bodies of that fact.

Mr. F. R. Upton—I think that we have heard a paper which puts the insufficiency of the candle-power test more clearly than it has ever been put before. I never have heard it expressed so clearly. I never have heard before so good and full an expression of what candle-power means. For the last few years there has been much discussion regarding candle-power. What Professor Nichols has said as to the amount of light that a low candle-power would give for illuminating purposes is very striking. Observe fire, and you will notice how it will illuminate the buildings around, and yet the candle-power is low. Where you have a glow of coal, the candle power is very low, yet the illuminating power, that you can see by, is very large. As to the artificial or fixed method of rating candle-power, I consider that the present custom of calling an incandescent lamp 16 or 20 candle-power is entirely wrong. Incandescent lamps are simply sorted. You put them in at 100 volts or 105 volts, so that they will be even if burned. That is all it means practically. Each consumer of light should fix the candle-power to suit the conditions. The marking that is now done on incandescent lamps is merely nominal; that is, it is in the hands of the parties who use the light to make the candle-power as much as they like.

I wish to express my pleasure at the production of such a paper as we have just heard. It is of the class that we want. We want more of them in these meetings. It brings to us the results of laboratory work, such as is now being carried on at Cornell, and when we can get such papers we can count ourselves very fortunate.

Dr. Otto A. Moses—The concluding remarks of Professor Nichols open up, I think, the proper field for us to cultivate; that is, the method by which we can arrive at some photometric standard. The method that he proposes has one very great difficulty. Carbon depends for its atomic condition upon the degree of temperature at which it has been distilled; that is to say, with every degree of increase of temperature you get an increase of carbon in the contents of the filament, the hydrogen being driven off. There were some experiments carried on in the laboratory where Professor Nichols and Mr. Upton were at work, by Professor Young, of Princeton, in which he determined that with an increase of incandescence in the filaments there seemed to be a diminution in the hydrogen of the filament, up to the point of the destruction of the filament, when the hydrogen seemed to disappear. That observation was made by him, and I think by Professor Brackett, proving that you are getting an increase of density in that carbon filament for each degree of increase of temperature. If you are to have a standard for photometric capacity, that standard should also be a definite heat capacity. The amount of light given off for different metals would vary according to that capacity, and you are getting for each increase of temperature in the production of that carbon filament a different degree of density, and consequently it would be impossible to take the dimensions and amount of current consumed and from those two deduce the limit of candle-power. The experiment where light was decomposed seems to be perhaps the most pregnant one for us to derive a photometric method from; for as in the decomposition of light we could recompose after we had determined the limits of action of each one of the colors of the spectrum, it might be possible in that way to get some definite summation. If it were possible to surround the light-giving centre with some sphere consisting of a film of definite thickness and containing a certain quantity of a substance to be acted upon by the light, it would be possible by superposing such films, to get, I imagine, what would be the summation of the chemical actions of all the different colors in the spectrum. In that way, by dissolving out from this film the soluble portions and determining the insoluble matter, it would be possible, by a chemical method, to arrive at the total chemical action on all those films and in that way make some definite approach to what is the real energy expended by the light.

Professor Nichols—If you are not all quite tired of me, I think I could perhaps make the last point a little clearer. The slide did not quite do its duty there, I think, in bringing out the relationship between the various wave lengths of radiation of four lamps all of which give the same candle-power, and from that I think I can indicate to you the line along which I would suggest a change of standard. I will take a piece of chalk and draw a diagram which will perhaps will be a little clearer. (Professor Nichols here repeated figure 10 on the blackboard.) The spectrum is assumed to be of unit intensity throughout. This is the yellow (indicating); here is the red; out here is green, blue and then violet, which is the limit of the spectrum. Now, if you have lamps of the same type of carbon, we will say—to illuminate all these questions that Dr. Moses suggested as to different carbons—this state of incandescence is that which corresponds to a 16 candle-power lamp of to-day. Take this same lamp and run it at a temperature which corresponds to a 4 candle-power to-day, and make that lamp large enough so that the photometer says it gives 16 candles, we find a curve like that which I had in my diagram, of this variety. Here are two lamps, one 16 and the other 4 c. p., and the photometer says that they are the same, but they are not the same either in total amount of energy, as one of my tables showed you, or in luminous effect; and if we run that on to 28 candles we find the red very much weaker, and the blue correspondingly much stronger. And there are three lamps, all of which the photometer says gives 16 candles, and yet they vary in total luminous energy and in total light-giving value as measured by their luminosity. At any rate, for a single type of carbon, prepared according to a certain process, and I believe it will hold through very closely of all filaments, if you know the state of incandescence, the temperature and the radiating surface, you have got a complete definition of the performance of that lamp, and you can then express exactly what it will do for any purpose for which you design it. If you want colors you use it at high incandescence. If you want the greatest possible reading power you will get a maximum for that also. You may have lamps which will give very different values when measured in these more exact ways, and which give the same value by the Bunsen photometer.

In the case of the 16 candle lamp raised to 50 candles, amounts to 10 per cent. As between the incandescent lamp of 16 candle and the arc light, the ratio between candle-power and luminosity is 4 to 5 merely. When we come to compare candle-power with daylight, one is half as good again as the other, and the ratio is 4 to 6. That is, a man who would give us 16 candles of a light like daylight would be giving us practically half as much again as he would give us with 24 candles. The man who gives us candle-power for candle-power of light of the quality of commercial arc light, as 5 to 4, 16 candles of his light are worth 20 of the 16 candles of the incandescent lamps. He who brings his incandescent lamp to a state which corresponds to 50 candles, gives us about 10 per cent. more, measured according to the luminosity, and yet we still are satisfied with the candle as our measurement of the performance of lamps.

Mr. Joseph Wetzler—Professor Nichols has outlined in a suggestion the method which he would pursue to get at the correct method of measuring the illuminating power of the lamp, and his method would consist in obtaining the radiating surface of the filament and its temperature. I would like to ask if he has attempted any practical way of carrying that out. Naturally it would seem that the determination of the radiating area of a filament would be easy to accomplish, knowing its size and the contour of its surface, and then would come the question of the temperature of the filament. It strikes me that if we knew the rate of variation for any particular carbon, the rate of variation of resistance for the increase in temperature, that that might be comparatively easily accomplished. I would like to know if Professor Nichols has worked in that direction. We would have merely to measure the resistance of the carbon; by a method similar to that of the Siemens pyrometer we could obtain its temperature, and then, having the temperature and the area, we could get at the value which he suggests.

Professor Nichols—I have been very much discouraged from attempting that, on account of some very singular results which Professor Anthony obtained some years ago, and which I think he reported to the Institute at that time, in the matter of the behavior of incandescent lamp carbons as to resistance at high temperatures. He came across a number of lamps in which the curve of resistance with increase of temperature turned upon itself. (See ELECTRICIAN AND ELECTRICAL ENGINEER, page 245, vol. vi.) Phenomena of that kind rather deterred me from that method of getting at the temperature of the carbon. But I think there is a hope of getting an optical method—an instrument by which you can look directly at the light and see what is its temperature in degrees centigrade. I think it would be premature to speak of that now, but possibly at some future meeting I may be able to report progress on it.

Dr. Moses—Mr. Upton, I am sure, will be able to answer some of these questions for us. In the manufacture of carbons from bamboo, the carbons are made of certain dimensions. They are then submitted to approximately a definite temperature, but it is found that they vary considerably in their resistances. Nevertheless, being of the same dimensions, and the carbon, when rendered incandescent, being brought up to certain definite temperatures for definite amounts of current, irrespective of the resistances in the beginning, it would seem that when definite amounts of current were passing, that in spite of this variation in resistance you would finally get the same amount of light, having these dimensions and the same material to act upon and the same temperatures ultimately; the temperature in this case being brought about by the current. Now, would Mr. Upton tell us about what would be the variations in carbons when of the same dimensions—when any given lot of them are put into lamps?

Mr. Upton—The ohms vary, of course, from accident. The one constant is the candles per horse-power.

Dr. Moses—But a definite fact is the amount of current that you allow to pass through them in testing them for their illuminating power. If you were to allow a definite amount of current to pass through those lamps, would you not approximately get the same amount of illumination, irrespective of the initial variation in resistance?

Mr. Upton—You are stating in a few words a pretty large problem. Of course, the question of the quality of the carbon comes in in a very large degree. The one constant, as I said, is the candle per horse-power. The carbons will vary, of course. Referring to what Professor Nichols says about the falsity of photometer measurements, many of us know that where lamps run a little bright how much more effect can be gained for certain purposes. A greater effect would be obtained for certain purposes far in excess of the increase of candle-power. That has been noticed in store lighting where colors come in, and Professor Nichols has explained it. There is another point about lighting that was not mentioned, and that is that there is a physiological effect of lighting; we used to notice that. The moment you get lighting up to a certain brightness, it has a cheering effect. If you get it dull it has the opposite effect, though both may be giving the same candle-power.

Dr. Moses—When you take carbon filaments of definite dimensions and bring them up, say, to a power of 48 candles and keep them there for some time, you then cook them and get them at just the very condition at which you can make these tests. Now, by passing a definite amount of current and bringing them up to the temperature as closely as we can calculate that will give 48 candles, would you not then get the same amount of candle-power from all of these? That question answered would determine whether it was possible to use this filament as a photometric standard.

Mr. Upton—As I said in reference to using a filament for a photometric standard, carbon varies in its surface, and you must specify your carbon and specify its carbonization before you can take that as a standard. You take a black carbon or gray carbon or polished carbon, and all the grades running between those, and you will have a variation from the same amount of surface in candle-power. The dimensions do not fix the candle-power. It is the quality of the surface that fixes the candle-power to a large degree.

Dr. Moses—But may we not get the right quality of surface by bringing the filaments to the same high intensity—by using a definite amount of current and then determining whether those carbons do not furnish at the same amount of horse-power consumed the same amount of light?

Mr. Upton—No. Take a thin flashed carbon; you bring that up highly and lose some of the flashing, and that has changed its quality; but the power that it will take to give light will change. There is a constant that runs through incandescent lamps that depends on the surface. Temperature does not fix it, as far as I know. But to measure the temperature of the filament itself is a very difficult matter. I do not know how to do it at present.

Dr. Moses—In making filaments from vegetable fibre, care is taken, I believe, to have them all from the same radial distance from the axis of the plant, so we may consider that the material is homogeneous and uniform. When we raise a body to a high temperature, we drive off by distillation those substances that may be distilled off, and if we get a definite amount of temperature by putting a definite amount of current through a definite parallelopipedon of carbon, then we will get a definite amount of illumination. Now, would not all carbons of the same dimensions —all similar carbons—give exactly the same amount of light? My reason for pressing the question is to determine whether the suggestion of Professor Nichols may not ultimately be taken as the definite photometric standard.

Mr. C. O. Mailloux—The constitution of carbon as found in the incandescent lamp is largely artificial, and is dependent greatly upon the method of treatment of the lamp. The value of a carbon filament would depend, other things being equal, on the density of the carbon. Its density has some relation to its color, and, again, the color has some relation to the condition of the surface, whether granular, crystalline, or smooth and polished. It occurs to me that this point of the density of the carbon will have some weight in the problem of the efficiency of incandescent lamps, and I have thought so ever since that paper was read by Professor Anthony, which Professor Nichols alluded to just now. May it not be that this variation of resistance in the incandescent lamp filament is one which instead of being abnormal is perfectly normal and characteristic of the carbon? I mean, of course, carbon in a highly incandescent state. May it not be that the resistance of the carbon is a function of its density—that it varies with the density of carbon as a material, and that this attains a minimum at a certain point. Now, the reason I speak of that is that I am brought to it by a certain analogy with substances which are perfectly familiar to us—electrolytes. I have had considerable experience in electrolysis, and in connection with that kind of work have had to determine the specific resistance of a great many substances, and I find that a great many substances have a particular density at which they give the minimum resistance. For instance, with sulphuric acid, you find that the curve is a very peculiar one, and that a very small increase at first in specific gravity, where you start with pure water, will make a very large decrease of resistance, but that by the time you reach a specific gravity of 1.2 you have reached very nearly the minimum; and if you go beyond that, the resistance increases, and finally when the sulphuric acid is at its maximum density its resistance becomes quite high; and the curve which it traces presents a very striking analogy to those which Professor Anthony presented before the Institute in his paper read last May. May it not be that we have here to deal with a phenomenon which is entirely normal, and that when we once determine the particular law which would appear to be involved here, we would have right there a means of measuring the efficiency of the lamp? With the current used in it and with the temperature and with a great many other conditions, it seems to me quite evident that having found an expression for the law which connects the density of the carbon with the temperature or with the resistance in some way, that we shall have made some step toward the finding of a practical method of gauging the efficiency of incandescent lamps. As I understand it, Professor Nichols states that the ideal method would be one which would be based on the radiation of the energy from the filament of the incandescent lamp itself, and if that were the case it looks to me as though you must look right there for the path leading to the proper solution.

Dr. Schuyler S. Wheeler—It seems to me that the most import-

ant measurements to be made of lights are when they are actually existing—not to be predetermined; and for that reason I would like to know if Professor Nichols thinks that the sum of the photometer readings of a light in different parts of the spectrum represents its real value?

Professor Nichols—As I understand it, we have to multiply the photometer reading in each part of the spectrum by a factor which itself is a function of the wave length and which expresses the light-producing power of that particular wave length. You have a light of a given kind. You see the distribution of energy in the spectrum from the violet to the red, and you take the sum of those wave lengths right down; taking the integrated value of this energy; that is, the area enclosed by the curve; that is the quantity which I speak of as the total luminous energy or radiation; but that is not the light-giving power. The light-giving power varies enormously in different parts. Part of the yellow, with slight variation so far as its actual energy is concerned, has a value representing several hundred times that of the extreme yellow, and out of the red we get great energy and little light-giving power; and at the end our luminosity ceases. We have to take the product of each wave length—of the amount of energy—into its luminosity as determined by one of the methods described; that is, the power which that particular wave length has in enabling us to read fine print.

If we have blue light and yellow light and bring them to the same brightness, so that to the best of our judgment we would say that they were equally bright, we can read fine print in the yellow and can not read it in the blue. In other words, the power of the blue to enable us to distinguish print is less. It is of no value, practically, for that purpose. What enables us to distinguish black characters on a white ground is the half of the spectrum which lies toward the red, and the rest might as well be thrown away. In almost all uses that we have for the electric light this thing that Mr. Upton spoke about comes in—namely, that indescribable value which we cannot express; that thing which brings out the colors in the art galleries and in our rooms. That lies largely in the violet; so that I think the value of light increases with its incandescence faster than with its luminosity. It is a factor which must be determined for each case according to the purposes for which you intend to use the light.

Mr. Dobby—I would like to ask Professor Nichols if he has thought of a photographic method of determining this point. There are three points in the spectrum which could each be determined by a plate specially prepared for it. For instance, a dry plate can be colored by aniline dyes; it has to be specially sensitive to one particular ray. As the question of lighting is a commercial question, might it not be a practical thing to determine the power of the lamp in a special part of the spectrum by a plate, and give it that value and state in what part of the spectrum its value was given?

Mr. Birdsall—As it is known that ordinary silver salts are more sensitive to the blue and violet rays than to others, and almost wholly unaffected by the dark red rays, that would seem to give us a means of measuring the most desirable rays for colors, namely, the violet rays; but it is also a fact that good photographs have been taken in almost absolute darkness to ordinary eyes. In other words, the violet rays past the visible end of the spectrum have the power to affect the sensitive plate, and in that way in Germany photographs have been taken at night.

Mr. Mailloux—I believe that it will be found possible to measure the energy of the incandescent light. I have great faith in the calorimeter, and I believe in the method which was outlined this evening by Professor Nichols. I do not see that there are any physical impossibilities in the way of arriving at a method by which we can differentiate the several kinds of light and find out the law connecting them together. Having done this, then it occurs to me that we could express the efficiency with reference to the properties for which the light is to be used, and that we could have a formula—a sort of modulus—by means of which the varying conditions of the use of the lamps would be taken into consideration in estimating their particular efficiency.

The Chairman—It is long past our usual hour for adjournment, but we have very far from exhausted the subject. It is, in fact, impossible to begin to exhaust such a subject in an evening's discussion. I think we appreciate our own ignorance in dealing with such a subject. It is remarkable how far in advance our own speculations and ideas of the subject are of the ideas which are ordinarily entertained by the public, and while listening to the discussion this evening as to candle-power, I was reminded of an incident that occurred last week in Bristol, Pennsylvania, where one of the large drug stores of the town was illuminated by candle at the time of the starting of the incandescent lamp. The druggist had heard that the incandescent lamps were of 16 candle, and in order to show how poor and insignificant the new illuminant was, he decorated the whole of his window with 16 candles. The result of the illumination was not as great a success as he anticipated, and he was overwhelmed with offers of the loan of snuffers on all sides. Although the incandescent lamp compared so favorably with the candles that were shown by the Bristol druggist, I think we have before us a great deal to do with the improving and perfection of our arc and incandescent lamps in order to secure a greater efficiency and in order to be less wasteful. The lines of one of England's great poets occur to me in that connection. You may remember them; they are those in which Tennyson says:

> "Our little systems have their day,
> They have their day and cease to be,
> They are but broken lights of Thee,
> And Thou, O Lord, art more than they."

And when we can get our own broken lights somewhat nearer the perfection of daylight we shall have done some of the work which awaits us. Of course Tennyson, in speaking of "our little systems" having their day, did not have in mind the systems which we see in such rapid process of consolidation with other larger systems. At the same time I think he hinted at a very great and singular truth. Adjourned.

ELECTRIC LIGHT AND POWER.

The Edison Illuminating Co., of Brooklyn, through their manager, Mr. Field, has just awarded one of the largest steam engine contracts ever placed in New York, for 12 Ball automatic compound engines of 250 h. p. each, to Charles R. Vincent & Co., of 15 Cortlandt street. These engines will be placed in the new central Edison station in Brooklyn, and will mark the latest development in high speed steam engineering, it being Mr. Field's intention to make this plant a model one in every respect.

The Heisler System on the Pacific coast at East Portland, Ore., has made a stout fight with the gas company of that city, and obtained the contract for 125 30-c. p. street lamps. The circuits are said to be 12 miles in length, using No. 8 B. & S. gauge of wire, and it has been stated by local papers that the lights are very satisfactory to the council and citizens. The plant and circuits will be enlarged and extended by Mr. H. A. Hogue, proprietor of the central station, so as to enable him to furnish commercial and private house lighting from the same station. This makes six central station plants of the Heisler system on the Pacific coast, most of them furnishing street, commercial and private house lighting from one central station plant on very extended circuits.

The Electrical Accumulator Co. has completed installation of 112 "15A" cells with Otto gas engine, together with all necessary switches and appliances, in the elegant Chicago residence of Potter Palmer, of Palmer's hotel. The plant was turned over on February 18, everything working perfectly. The lamp service was remarkably good. Through the courtesy of Mr. Conant, representing the Electrical Accumulator Co., in Chicago, members of the Electric Light Association and visitors at the recent convention in that city were given opportunity to inspect the installation at Mr. Potter's house. Those who availed themselves of the privilege were much impressed with the success of the accumulator plant.

An Electric Transfer Table at Altoona, Pa.—The Sprague Company have recently installed an electric transfer table, operated by one of their electric motors, for the Pennsylvania Railroad, at Altoona, Pa. The motor is of 10 h. p., and its speed is controlled and the direction of rotation changed, by a Sprague patent switch, carried on the table itself. The power for operating the table is taken from the engine operating the main-shops, about 500 to 600 feet away from the table. Here there is stationed an Edison dynamo which generates the necessary current for operating the motor.

The Thomson-Houston Company.—On the 27th of February, the Legislature of Connecticut authorized the Thomson-Houston Electric Light Company to increase its common stock from \$1,000,000 to \$10,000,000, and to issue \$5,000,000 of preferred stock. In addition to increasing the capital, the resolution empowers the company to buy or lease plants for electric light, heat, power, or electric railways, and to buy stock and bonds of electric lighting and electrical companies, illuminating and carbon companies, and railroad companies whose roads may be operated by electricity.

The stockholders have been notified of a special meeting at New Britain, Conn., April 2, to determine, *First:* Whether the company shall increase its common capital stock by \$2,000,000, so that the total shall be \$3,000,000; upon the following plan: A—\$1,000,000, representing present earned and undivided profits of the company, as a stock dividend to present stockholders, one new share for one old share held, transfer books closing from April 9 to 14, inclusive, certificates of new stock to be deliverable April 15, such stock not being assignable before the issue of certificates, and rights thereto not being assignable. B—The other \$1,000,000 of increased capital to be sold and issued for cash, stockholders of record April 8 to have the right up to April 12 to subscribe therefor in cash at par, \$25 per share, one share of new for each share of present stock held. The rights to subscribe to this new stock are to be assignable up to April 12, after which stock not subscribed for will be sold by the directors for cash, not below par. *Second:* To determine whether the company shall issue \$1,000,000 preferred stock, making the total capital \$4,000,000, \$3,000,000 common and \$1,000,000 preferred, said pre-

ferred stock to receive seven per cent. per annum in dividends, payable semi-annually, to be sold for cash at not less than par, and to be issued from time to time in such manner as the directors may determine. *Third:* To appoint a committee to draft a new or amended code of by-laws, to be submitted for approval at the next annual meeting. *Fourth:* To see if the stockholders will vote to change the office of the company and the place of holding the annual and any special meetings from New Britain to some other place in Connecticut.

THE ELECTRICAL ACCUMULATOR COMPANY commenced a second suit in equity, February 15th, against the Julien Electric Company, charging infringement of the Sellon patent, for the use of an alloy plate in secondary batteries; damages and an injunction are asked for. The same corporation has also instituted suit in equity against the Gibson Electric Company on three several patents of Faure, Swan and Sellon, for improvments in secondary batteries.

Foreign.

Austria.—The "Unionbank," of Vienna, has made a preliminary agreement with Messrs. Ganz & Co., of Budapest, with the object of forming a large electric light and power company, under the title "Allgemeine Osterreichische Elektrizitätsactiengesellschaft." The bank offers to undertake the financing and floating of the company, the share capital of which is fixed at 2,000,000 florins (about $775,000), whilst Messrs. Ganz & Co. undertake the technical management and the supply of the machinery required.

The town council of the watering place of Marienbad have, at a recent meeting, unanimously resolved to adopt the electric light for the streets and all the municipal buildings, and the order for the installation was given to Messrs. Ganz & Co. The station is intended for the supply of 1,250 glow lamps in private houses and municipal buildings, and 35 arcs for street lighting. According to the present plans, the generating plant consists of two 50 kilo-watt alternators, each driven direct by a separate steam engine. The site for the station is about a mile and a half from the town, and the current is to be distributed by overhead wires. The transformers for the public lamps will also be fixed overhead, on posts, and protected by iron casings, as in the Westinghouse system. All the arc and glow lamps will be arranged in parallel. The total cost of this installation is estimated at about $38,000.

France.—THE ELECTRIC LIGHT AT THE BON MARCHÉ, PARIS.—At a recent meeting of the International Society of Electricians, M. Cance read a paper describing the electric light installation at this large emporium. This installation is interesting not so much on account of the machinery and apparatus employed as on account of its magnitude. It resembles rather a central station than a private installation. The total steam power employed amounts to no less than 900 h. p., and there are various types of dynamos in use, viz., Gramme alternators, Gramme direct current machines, and Edison machines. A great part of the lighting is carried out by Cance arc lamps placed in parallel on a 70-volt circuit, with additional resistance, to make them burn steadily.—*Industries.*

CENTRAL STATION LIGHTING IN PARIS.—The various schemes for the public supply of electricity in different quarters of Paris have been in abeyance for a long time, but there seem at last to be signs of progress. The municipality some time ago instructed M. Lyon-Alemand to examine the various projects elaborated by different companies, and on Saturday his report was accepted by the council. The following are the firms or companies which propose to have a share in the lighting of the town, each taking what is known as a "sector:" 1. La Compagnie G. Sencier; 2. La Société d'Eclairage Electrique de la Place Clichy; 3. La Société Anonyme pour la Transmission de Force Motrice par d'Electricité (Société Marcel Deprez); 4. La Société Continental Edison; 5. La Compagnie d'Electricité Victor Popp; 6. La Compagnie Parisienne Electrique.

Switzerland.—ELECTRIC RAILWAY IN BURGENSTOCK.—The track of this road is only some 3,000 feet long, but the difference of level between the two extremities is about 1,400 feet, giving thus a mean gradient of over 50 per cent. The gradient is not quite uniform, and the upper part gives a rise of 57.7 per cent. Water power is used and the transmission is effected electrically. The electrical plant has been furnished by Messrs. Cuénod, Sautter & Co., of Geneva. Two cars are used, which counterbalance each other, that is to say, one ascends whilst the other descends. The electric power, therefore, serves merely to overcome the friction of the apparatus and to counteract the differences of loads in the cars, and the power is said to be very variable. The current is generated by two dynamos, with a capacity of 30 h. p. The circuit extends over a distance of about 2½ miles, leading to two motors.

NEW INCORPORATIONS.

Electric Light and Power Co., Beardstown, Ills., H. Ehrhardt and others. Capital, $20,000.

Maywood and Proviso Electric Light and Power Co., Maywood, Ills., Joseph Jennings and others. Capital, $20,000.

Bankers' and Brokers' Telegraph Co., Steubenville, O. Capital, $50,000.

Bowling Green Electric Light and Power Co., Bowling Green. O. Capital, $10,000.

Baker County Telegraph and Telephone Co., Salem, Ore. H. C. Bowers and others. Capital, $30,000.

University Electric Street Railway Co., Denver, Col., G. W. Bailey and others. Capital, $75,000.

Thirty-first Street Merchants' Electric Light Co., Chicago, Ills., John McDermott and others. Capital, $20,000.

Benton Harbor and St. Joseph Electric Light Co., Benton Harbor, Mich., I. W. Conkey and others. Capital, $25,000.

Toronto Electric Light and Power Co., Toronto, O. Capital, $15,000.

Hagerstown Electric Co., Hagerstown, Md., Charles E. McKee and others.

Curtis Electric Light and Power Co., Portland, Me., A. J. Adams and others. Capital, $800,000.

Electric Liquid Controller Co., Richmond, Va., T. N. Motley, of New York, and others. Capital, $50,000.

Easton Electric Light Co., Newark, N. J., Henry D. Lyman, of New York, and others. Capital, $1,000,000.

Leonard and Izard Co., Chicago, Ills., H. Ward Leonard and others. Capital, $300,000.

Evanston Electric Light and Power Co., Evanston, Ills., John S. Philip and others. Capital, $30,000.

Municipal Electric Power Co., of New York, T. F. Hayes and others. Capital, $100,000.

Olympia and Turnwater Railway, Light and Power Co., Olympia, W. Ter., Edward M. Wilson and others.

Merchants' Electric Light Co., Seattle, W. Ter., Jno. D. Lowman and others. Capital, $50,000.

Millard Avenue Electric Co., Chicago, Ills., George Martin and others. Capital, $25,000.

Harvard Electric Light Co., Harvard, Ills., W. Fay and others. Capital, $16,000.

Jefferson Rapid Transit and Electric Lighting Co., G. H. Parker and others. Capital, $250,000.

Lewistown Electric Light, Heat and Power Co., Lewistown, Ills., L. N. Ross and others. Capital, $10,000.

Elkhart Electric Light and Power Co., Elkhart, Ind., J. N. Lumbert, president. Capital, $10,000.

New York Construction Co., of Chicago, Ill., S. G. Clark and others. Capital, 30,000.

Sperry Light and Power Co., Chicago, Ill., Sam'l P. Parmly and others. Capital, $100,000.

Gas and Electric Co., Middleboro, Mass., N. E. Wilbur and others. Capital, $30,000.

West Side Electric Light and Power Co., New York, Elsworth L. Striker and others. ———

Century Electric Co., Newark, N. J., T. G. Brown and others. Capital, $100,000.

Electrical Engineering and Construction Co., Chicago, Ills., M. E. Willard and others. Capital, $600,000.

Bogota Electric Light Co., Albany, Ills., A. Lagenvach and others. Capital, $100,000.

Maine Electric Light, Gas and Water Co., Rockland, Me., A. F. Crockett and others. Capital, $1,000,000.

Beverly Electric Light and Power Co., Beverly, N. J. Capital, $50,000.

Abington Electric Light and Power Co., Abington, Mass., J. R. Lovejoy and others. Capital, $25,000.

Troy Electric Dynamo Co., Troy, N. Y., Justus Miller and others. Capital, $20,000.

National Automatic Fire Alarm Co., Washington, D. C., Van H. Manning and others. Capital $350,000.

Taylorville Electric Light and Power Co., Taylorville, Ills., W. W. Andrews and others. Capital, $20,000.

Evanston District Telegraph and Electric Co., Evanston, Ills., F. M. Winters and others. Capital, $25,000.

Lakeside Electric Light and Power Co., Chicago, Ills., D. Barclay and others. Capital, $30,000.

Columbia Electric Light, Heat and Power Co., J. J. McEvoy and others. Capital, $15,000.

People's Electric Light Co., Chicago, Ills., John J. Curran and others. Capital, $50,000.

Merchants' Arc Light and Power Co., Chicago, Ills. Capital, $60,000.

Electric Street Car Motor Co., Chicago, Ills., W. S. Salisbury and others. Capital, $250,000.

MANUFACTURING AND TRADE NOTES.

MESSRS. SPAULDING AND BUCK, 620 Atlantic ave., Boston, have secured the New England agency for the "Eddy" motors. The same territory has been secured for the Continental dynamos.

THE ELEKTRON MANUFACTURING CO., of Brooklyn, N. Y., has opened an office at 150 Nassau street, New York, under the charge of Mr. E. H. Cutler, manager of the company. This company manufacture the "Perrett" motors, which have attracted so much attention of late.

THE EMPIRE CITY ELECTRIC CO., 15 Dey street, will now receive the benefit of Mr. E. T. Gilliland's extensive experience in the manufacture and sale of electrical supplies. The recent lease of a large factory is an indication of the scale upon which this company intends to do business.

THE FORT WAYNE JENNEY ELECTRIC LIGHT CO. has scored another victory in the sale of its alternating system to the West Side Electric Light and Power Co., of New York city. The West Side company has an excellent field, and the demand for lights has already far exceeded expectations. Mr. W. H. Cole is general manager and electrician.

MESSRS. J. ELLIOTT SHAW AND CO. announce that they have succeeded to the business of Messrs. Shaw and Geary, 53 and 55 N. 7th street, Philadelphia.

THE NATIONAL ELECTRIC MANUFACTURING CO., of Eau Claire, Wisconsin, announce that they are prepared to furnish an alternating system of incandescent lighting, having purchased the patents of Mr. Walter K. Freeman.

HILL CLUTCH WORKS.—Mr. Walter C. Wonham, manager of the eastern office of the Hill Clutch Works, 18 Cortlandt street, New York, reports that the business is constantly increasing, and that they have recently made large shipments of their friction clutches and power transmission machinery to the following points:—Buffalo, N. Y., New Brunswick, N. J., Boonton, N. J., Wilmington, Del., Schenectady, N. Y., Newark, N. J., Boston, Mass., Troy, N. Y., Peabody, Mass., Providence, R. I., Gardner, Mass., Ocean Grove, N. J., Paterson, N. J., Derby, Ct., Lawrence, Mass., Baltimore, Md., Baldwinsville, N. Y., Albany, N. Y., and New York city, and have booked orders from the Fitchburgh Steam Engine Co., the Cyclone Pulverizer Co., Edison Machine Works, the Pusey and Jones Co., the Robinson-Foster Electric Railway Motor Co., Narragansett Electric Lighting Co., F. W. Ehrsam, Benjamin Eastwood, the Derby Gas Co., Hewes and Phillips Iron Works, Jno. B. Adt, and the Lehigh Valley R. R. Co.

MESSRS. W. R. OSTRANDER & CO., 21-25 Ann street, New York, have introduced a new and simple door opener for apartment houses and flats. The movement is a gravity one, and it is devoid of any delicate springs or complicated mechanism. This door opener can be operated either by electricity or compressed air. Both forms are supplied by Messrs. Ostrander.

THE PHILADELPHIA OFFICE OF THE FORT WAYNE JENNEY ELECTRIC LIGHT CO., G. A. Wilbur, manager (lately at 26 N. 7th street), has removed to No. 907 Filbert street.

A VERY fine exhibit was made at the last American Institute Fair by the Jerome Kidder Manufacturing Co., 820 Broadway, New York, makers of Dr. Kidder's electro-medical apparatus. The company produces an exceptionally fine line of medical apparatus, batteries, etc. They have received the highest awards from the Institute since 1872. They show a full line of galvanic batteries, galvano-caustic batteries, many styles of faradic batteries for family and physicians' use, tip batteries, surgical instruments, cauteries and special appliances for a large variety of medical and surgical operations.

MESSRS. JAMES W. QUEEN & CO., of Philadelphia, who have gone so largely into the supplying of electrical testing instruments during the last few years, have done much to develop the home manufacture of such apparatus. Their rheostats and combination testing sets have already acquired a reputation for finish and, better still, for accuracy. Their high-class work is certified by Professor Wm. A. Anthony, a most satisfactory guarantee of its excellence.

THE WOODHOUSE & RAWSON CO., of London, announce the receipt from Melbourne, Australia, that a first-class award has been made to them for their display of electrical apparatus at the exhibition there.

MR. GEORGE O. FAIRBANKS has been appointed general district agent of the Westinghouse companies for the states of Illinois, Indiana and the Michigan peninsula.

THE WESTERN ELECTRIC CO., of Chicago, received an award at the Melbourne Exposition, Melbourne, Australia, for its exhibit of electric bells, annunciators, etc.

THE firm of Shaw and Geary, Philadelphia, has been dissolved by mutual consent. The electrical manufacturing business will be continued at No. 53 N. 7th street, under the name of J. Elliott Shaw and Co.

THE E. S. GREELEY & CO., of New York, have designed and manufactured and offer for sale a small and compact Wimshurst electric machine, with special reference to the wants of students and experimenters. They also provide convenient accessory apparatus and publish a tasteful little pamphlet (from which they have, too modestly, withheld their name) containing some account of the machine and its accessories, and directions for a few experiments. Such an outfit for the initial study of static electricity, or for entertaining experiments, is sure to be appreciated very widely in these days, when everybody wants to know something about electricity.

OKONITE wire is reported to meet with a brisk demand from all parts of the country. The Standard Electrical Works, Cincinnati, representatives of the Okonite company, have just closed a large contract to furnish the Cincinnati Railway Co. with Candee aerial wire for their main lines. The new Chamber of Commerce building, Cincinnati, has also recently been entirely installed with Okonite wire through the Cincinnati office.

MESSRS. E. E. GARVIN & CO., of this city, manufacturers and dealers in machinery, notify their customers and friends that they have secured a long lease of the new building at Laight and Canal streets, and will take possession about April 1. The firm's new quarters afford room for largely increased facilities for manufacturing. Their plant will be a modern one, and all necessary tools for the proper and expeditious finishing of work will be introduced as fast as required.

THE AMERICAN INDURATED FIBRE CO., Mechanicsville, N. Y., are in the market with indurated fibre pipe for underground electric wires. Good insulation, durability, lightness and low cost are some of the advantages claimed for the use of these pipes as underground conduits. It is also claimed that they possess a high resistance to the action of heat and gases.

THE DEATH OF MR. FRANK SHAW.

The death of Mr. Frank Shaw, on Saturday, March 23, removes a familiar figure from the ranks of electricians in New York.

Mr. Shaw was a Virginian. He was born in the western part of the state (now West Virginia) in 1841. He began his electrical work in the Construction Department of the U. S. Military Telegraph at the head-quarters of the Army of the Potomac. After the war he took service successively with the American, the Western Union and the Gold & Stock Telegraph companies, becoming well acquainted with the practical side of telegraphy and particularly with printing and other stock-reporting methods. He afterwards spent some years in the City Fire Alarm Department, where, as an inspector, he greatly increased electrical and mechanical knowledge and experience. Soon after 1870 Mr. Shaw turned his chief attention to exchange systems of communication, and soon connected himself with the Law Telegraph Co., whose successful enterprise in building up an exchange printing telegraph system in New York. Dial instruments were first used, followed by printers. The telephone displaced both, but Mr. Shaw's ingenious inventions of circuits and devices for exchange work were equally available for the new instrument of communication, and the Law company's telephone exchange became distinguished for its excellent service. Mr. Shaw continued with the Law Telegraph Co. up to the time of his death. His eminently practical notions and his ingenuity enabled him to produce a number of electrical devices of much utility and value. His cleverness was shown chiefly in his apt arrangement and combination of circuits for exchange service and in ingenious designing and construction of switches for their manipulation. Mr. Shaw's untimely death will be deeply regretted in electrical circles, particularly by his many personal friends, to whom his genial presence was always a pleasure.

ALUMINIUM.

Aluminium—is as everybody knows a metal. But the remainder of everybody's knowledge of it seems to be rather of the abstract than of the concrete order.

Since it is steadily growing cheaper, and is said to be now producible at about 25 cents per pound, the time seems to have arrived when it ought to be looked at with increased interest by electricians. Here, therefore, are some of its characteristics gathered together for the benefit of the readers, of the ELECTRICAL ENGINEER.

Aluminium—not Aluminum.
Symbol Al. Atomic weight 27.3.
Equivalent 13.7.

Al—belongs to the so-called aluminium group, which includes also indium and gallium.

It is the metallic basis of clay, and its name is derived from *alumen*—alum.

Was first prepared by Wohler in 1827, is a tin white metal, and capable of assuming a bright polish.

Can best be worked at a temperature of 100° to 150° and fuses at about 700°.

It does not oxidize at ordinary temperatures. Has a specific gravity—when cast of 2.56 and when hammered of 2.67; and is extremely sonorous, emitting when struck a sound like flint glass.

It is about as malleable as gold and silver; is ductile, and can be drawn out into wires of extreme tenuity. When so drawn into very fine wire it deteriorates, and has to be carefully annealed before it can be used.

Tensile strength—Taking the strength of aluminium in relation to its weight, it possesses a mechanical value about equal to that of steel of 35 tons per square inch, tensile strength.

Electrical conductivity.—According to Deville, aluminium conducts electricity about as well as silver; but Fremy states that the conductivity of silver being called 100; that of aluminium is but

83.74. There are also other estimates, and the discrepancies as above are wide, but they are probably due to some of the comparisons being weight for weight, while others are size for size, and it would seem that Deville's statement should be held as weight for weight, which would require a much larger wire of aluminium, and Lazare Weiller confirms this view since he gives the relative conductivities of pure copper, and aluminium in wires of like size as being respectively 100 and 54.2. This metal is also slightly magnetic.

Thermal conductivity.—Al'. conducts heat better than either silver or copper, and its specific heat is 0.2181, which is greater than that of any other useful metal.

Aluminium bronze, it is likely, will continue to be the form in which aluminium will be most interesting to the practical electrician and electrical engineer. This is an alloy of aluminium and copper, has a color like gold, is extremely hard, and susceptible of fine polish; it is very malleable, and has tenacity equal to fine steel. It is already much used on the Continent of Europe for telephone lines, and will doubtless be employed to a much greater extent as it can be made more economically. Its conductivity is, however, low, being as stated by Weiller, but 12.6, where phosphor-bronze is 29, silicious-bronze for telephone wires 35, and pure copper, 100.

CORNELL UNIVERSITY.

Recent additions to the equipment of the Electrical Engineering Department of Cornell University include the following gifts:—A storage battery of 70 cells from the Brush Electric Company, a storage battery of 60 cells from the Electric Accumulator Company, and a complete incandescent light outfit from The Thomson-Houston Electric Company.

Professor Frank Van Vleck, formerly of Cornell University, is now engaged in electrical business at Los Angeles, Cal.

THE TELEPHONE IN SWITZERLAND.

The returns published by the Swiss Confederation with reference to the development of telephonic communication in Switzerland show that, since the establishment of the first telephone in 1880, 61 towns have been provided with it, and there are now 6,944 telephonic stations, of which no fewer than 1,500 are in Geneva and its suburbs. Most of the Swiss towns are now connected with one another, Geneva communicating not only with Lausanne and other places on the shores of the lake, but with Berne, Zurich, and St. Gall. The Confederation has taken over the telephones, which are attached to the department of posts and telegraphs, and the annual cost of subscription is only £6. Notwithstanding this moderate charge, the receipts exceed the expenditure by about £8,000, and the federal council now contemplates reducing the rate of subscription to £5 for the first year, £4 for the second, and 80fr. for the following years, with a trifling supplemental charge for those subscribers who use the instrument more than 500 times during the twelvemonth.

POINTERS.

.... THE definition of energy is capacity for doing work. We practical men are quite content to start from this fiducial line, and to affirm that our electricity is a something which has a capacity for doing work; it is a peculiar form of energy. The physicist may speculate as much as he pleases on the other side of this line. —*W. H. Preece.*

.... IN the sale of the Waterhouse system by its owners to the Westinghouse people, a strong financial company will acquire a first-class incandescent system (!)—*Electric Mechanic*, Dec 1888.

.... IT is my opinion that, with our present knowledge of machinery, a steam engine can be built that will produce a horse-power with three-quarters of a pound of coal an hour, if of sufficient size to reduce the percentages of loss by radiation to a minimum.—*E. N. Dickerson.*

.... THE development of the electric service of a city can not be accomplished without the co-operation of the corporation with its citizens.—*A. R. Foote.*

.... THE problem of the steam engine is to convert the potentiality of combustion into dynamic energy; and that steam engine is the best which can obtain the most power from the least coal.—*E. N. Dickerson.*

.... THE uses of electricity are limited only by the want of intelligence in producing fitting apparatus for its application. The demand for such apparatus is limited only by the want of intelligence on the part of the public to know how to use it properly.—*A. R. Foote.*

NEWSPAPER ELECTRICITY.

The rapid spreading of the technics of electric lighting is said to be devoid of a natural basis as long as there is no theoretical and practical soundness in the construction of dynamos.—N. Y. *Times.*

Indicators worked by electricity to prevent spontaneous combustion are being quite generally used on shipboard.

The skin is generally high resisting, while the conductibility of the bones is less than two-fifths of the other hypodermic tissues.

The coefficients used for the reduction of dielectric resistance do not progress arithmetically, but follow the laws of compound interest.

As far as can be seen, the only thing likely to interfere with the successful working of subways for electric wires would be an unexpected and rapid deterioration of the lead covering to the cables.

A strong blowpipe of oxhydrogen flame from one carbon to another sets up an E. M. F., which would fully account for the opposing E. M. F. of the arc.—N. Y. *Commercial Advertiser.*

THE PROPOSED BERMUDA-HALIFAX CABLE.—ITS USEFULNESS FOR WEATHER PREDICTIONS.

The announcement made on Thursday, March 21, by the British post-master general, that the government intended to lay a submarine cable between Bermuda and Halifax, will be good news to all Atlantic seamen and all American and European meteorologists.

Bermuda is a natural observatory for watching hurricanes emerging from the tropical ocean and threatening to assail the United States, or to advance northeast wardly from the Gulf Stream into the transatlantic steamer tracks, and subsequently to burst upon the shores of Europe. Of course an observer at Bermuda cannot see with the naked eye what a Gulf Stream storm is doing, or determine by ocular demonstration what its course will be. But by watching the fluctuations of the barometer at this mid-Atlantic station and by reporting them by cable to America and Europe, meteorologists on either continent will be enabled to feel the pulse of the storm, and to determine more accurately its intensity and its future movements. For purposes of weather and storm forecasting in our Atlantic states, therefore, weather cablegrams from Bermuda will be invaluable.

But if the interests of Atlantic navigation be consulted maritime nations should co-operate in an attempt to form a net-work of ocean weather observations both to the northwest and southwest of Bermuda. From Bermuda to Halifax is 750 nautical miles. This requires quite a long stretch of cable. A floating observatory could be anchored on the southeastern side of the Great Newfoundland Bank in 30 fathoms of water, and connected with the telegraph system at Cape Race by a cable only 200 miles long. With a telegraph station on the Great Bank—very near the main transatlantic tracks of steamers—it would be easy to obtain intelligence of the movements of Atlantic storms on both sides of the ocean. Moreover, all vessels crossing the Atlantic could be warned from such an observatory of the progress of dangerous storms and the movements of ice fields and icebergs in the main highways of ocean commerce.

The time is ripe for some international effort to be made to secure to the merchant marine the advantages of storm and ice warnings, which can only be done by the establisment of mid-ocean observatories. It is to be earnestly hoped that the International Marine Conference, which meets at Washington this year, will take up this subject.—*New York Herald.*

THE BELL TELEPHONE COMPANY'S ANNUAL MEETING.

The annual meeting of the American Bell Telephone Co. was held March 26. While the balloting for directors and other officers was in progress the annual report was read. It says:—

"Your directors, believing that part of the income from royalties should be treated as capital, have transferred $600,000 from the net surplus for the year to a reserve account. The company earned in the year 24.45 per cent. on the stock, and has assets of $258 per share. The long-distance service has been extended from Albany to Buffalo and new lines have been built from Chicago to Milwaukee, and from Boston to Providence. Additional pole line has been built from New Haven to New York. About $2,200,000 has been spent on long-distance lines, which now comprise about 26,083 miles of wire.

"The gross earnings of the year were $3,865,118; expenses, $1,450.913; net earnings, $2,414,205; total dividends, $1,789,878. Deducting a reserve for general depreciation, the surplus account remains the same as last year—$2,028,085. The number of exchanges is 742, an increase of three; branch offices, 452—no increase; miles of wire, 170,471—increase, 24,083; subscribers, 171,454—increase, 12,742; instruments under rental, 411,511—

it is contended that the patentee did not intend to limit the invention to the oxides or salts of lead not soluble in the battery fluid, but wished to include generally all substances as materials for covering the supports which are capable of absorbing or storing electricity, electrolytically. The patentee specifically states that the invention includes manganese. A support would be within the invention, therefore, if coated with the sulphate of manganese, which is a salt soluble in the liquid, though the oxide of its base is insoluble.

It is thought, then, that the language of the patent, although by no means clear, can hardly be construed to exclude a coating soluble in the electrolyte. Why the patentee, having invented a practical, efficacious and meritorious method, should have used language which apparently includes an inferior and comparatively useless one is, indeed, inexplicable. That it was intentional can hardly be imagined. If these conclusions are correct it follows that the claim should be construed to cover—

First.—A secondary battery as distinguished from a primary battery.

Second.—An (one) electrode in the battery capable, in conjunction with the other electrode, of receiving and discharging electricity as described

Third.—The said electrode formed of a plate of metal or carbon or any suitable non-metallic substance.

Fourth.—The active layer of sufficient depth and uniformity to operate successfully added to the plate in any suitable way as a paint, paste or cement, or electrolytically or chemically.

Fifth.—The active layer of spongy lead or any metallic compound capable of satisfying the conditions of the patent as to porosity, etc.

Sixth.—Any suitable electrolytic liquid.

The Court then takes up the question of anticipation together with the enquiry whether the real invention of Faure can be saved by a disclaimer of non-essential features inadvertently inserted in the specification.

Full discussion is given to exhibits and testimony introduced by the defendants to show anticipation and lack of patentable novelty, comprising publications, patents, and oral evidence, extending from De la Rive's use of peroxide of lead; the platinum plate secondary battery described in the Smithsonian Institution's report for 1856, to the experiments of Mr. C. F. Brush, in 1879, and subsequently. In none of the publications or testimony does the Court find satisfactory evidence of an anticipation of the real invention described in Faure's specification, viz., the application of the active material in the form of a paint, paste or cement.

Discussing the evidence of prior invention by Charles F. Brush, Judge Coxe says:—

In determining this question, Faure, being at that time a citizen of France, is not permitted to claim the invention earlier than the date of his French patent, which was October 20, 1880, and possibly not earlier than December 7, 1880, which is the date of the decree (*arrête*) under which it was delivered. * * * *

Mr. Brush testifies that in the latter part of 1878 he first became familiar with the discoveries of Planté, and learned that the lead plates constructed by him required several months of electrical treatment in order to produce the necessary active coatings on their surfaces. In December, 1878, or very early in 1879, he conceived the idea of making a secondary battery by applying mechanically to suitable plates an active or absorbing coating so that such plates might be used at once, after suitable charging, for electrical storage purposes without the tedious, preliminary forming process described by Planté. In the summer of 1879 he embodied this idea, making a secondary battery by applying to suitable plates or supports, by mechanical means, an active or absorbent coating. For this purpose he took a piece of sheet lead about three inches wide and about twelve inches long and sprinkled thereon finely divided metallic lead, in the form of a fine powder, which could be passed through a sieve. This layer was about one-sixteenth of an inch in thickness and it extended the whole width of the plate and about three-fourths of its length. The lead powder was held in place by blotting paper, the edges of which were turned back and under the plate at the sides and bottom. A narrow strip of wood was laid longitudinally on the blotting paper, and the whole was wound tightly with a string. This plate was suspended in a tall glass jar, nearly filled with dilute sulphuric acid, and formed the oxygen element of the cell. The hydrogen element was a plate of amalgamated zinc suspended opposite the prepared lead plate in the glass jar. Soon after the completion of this cell he prepared two more lead plates in exactly the same manner as the one described, and hung them both in a tall glass jar filled with the same electrolyte. In this cell one of the prepared lead plates formed the oxygen element and the other the hydrogen element. He connected this cell in a series with the one first described and charged it by means of the current from a dynamo-electric machine. The strength of the current was not measured, but it was somewhere about five amperes. He charged the cell several hours on each of several days before commencing to discharge it. He discharged it through a fixed and constant resistance and noted the time which the current lasted and was thus able to compare the performance of this cell quantitatively with that of other cells discharging through the same resistance. This resistance consisted in the helices of the electro-magnet of a single stroke electric call bell. Upon the passage through this magnet of the current from the secondary battery cells its armature was strongly attracted. He found that the electrical storing capacity of the prepared plates was very much greater than that of the Planté plates of the same size. During the first few weeks, after the construction of the cell with the lead plates as described, he discharged and re-charged it frequently, and sometimes daily. After that he always kept it charged, and discharged it less frequently up to May 1880. * * * * About the same time he made two other cells alike in every particular, except that the coating was, in one instance of red oxide of lead and in the other of litharge. He subjected these cells to the same treatment as the ones first described with substantially the same result. He says of these cells that "they were all completed, finished and operative storage batteries from the time of their construction and first charging up to the time of the fire when they were destroyed. They all operated successfully and reliably during that time."

All of the results obtained by Mr. Brush were carefully noted down and preserved, some in the form of entries in a diary and some on loose sheets of paper. On the 6th of May, 1880, his laboratory with its contents were totally destroyed by fire. His diary and the loose memoranda concerning his experiments were all lost.

The Court here recites from Mr. Brush's testimony further statements describing storage batteries constructed by him after the fire of May, 1880, including grooved lead plates, some having the grooves filled with yellow oxide of lead, and some with sulphate of lead.

After the fire in 1880 a full memorandum was kept of the experiments and results obtained. After Faure's patent was issued in January 1882, interferences were demanded by Brush and resulted in decisions in his favor at all stages during the progress through the Patent Office.

In many important features of his testimony he is corroborated by the evidence of three witnesses who were present and saw many of the experiments referred to. After the fire Brush undertook to reproduce from memory the memoranda which had been destroyed, and criticism is made that he does not describe with particularity the batteries which he now says he invented, though he does describe with great detail other and inconsequential experiments. It is unfortunate that his reproduced notes should be so meagre on the points in controversy, that his original apparatus should have been destroyed and that his battery of July, 1880, should have been lost. Improbabilities and inconsistencies in his statements are pointed out, and it is asserted that none of the experiments detailed by him amount to a perfected invention. Although it is unquestionably true that this proof might have been more convincing and satisfactory it is also true that there is nothing opposed to it but presumption conjecture and guesswork based upon its inherent defects. There is no fatal improbability, as in the case of the other alleged prior inventor, and the Court would not be justified in rejecting, for the reasons suggested, the testimony of four intelligent, respectable and apparently fair and honest witnesses. The testimony of Mr. Edmunds and Mr. Hayes is not inconsistent with the statements of Mr. Brush. It is not surprising that he did not care to disclose his experiments to Mr. Edmunds, and when they met and conversed in Paris his application was on file in the Patent Office. Nor does it avail the complainant that the Brush structures were experimental as distinguished from commercial batteries. If the invention was made it cannot matter how it was made or for what purpose. It is only where experiments fail to reach the desired result, and are abandoned as failures, that they are rejected as proof of want of novelty. They are not rejected when they are carried to successful consummation.

Waterman *vs.* Thomson, 2 Fish., 461.
Aiken *vs.* Dolan, 3 Fish., 197,203.
Walker on Patents, Secs. 63, 86.

The evidence of Mr. Brush as to what he accomplished in 1879 and 1880 must be accepted as true, and although Faure was *de facto* the first inventor Brush was *de jure* the first inventor of the electrodes described by him. It is not, however, contended for Mr. Brush that he applied the active layer to any of his electrodes in the form of a paint, paste or cement.

It, therefore, becomes apparent that the combination of the first claim, construed as it must be construed under the loose and inaccurate language of the specification, is anticipated in every form in which the active layer can be applied, save one, namely, in the form of a paint, paste or cement. The question now to be considered is, can the patent be saved to this extent? The application in the form of a paint, paste or cement was the real invention which Faure made. It was in this form that he gave it practical embodiment, it was this that the scientific world under-

stood to be his improvement. An electrode for a secondary battery with the active layer applied in this form has many undoubted advantages over an electrode otherwise coated. It can be applied more evenly; it more readily adheres to the support; it does not shift its position, it "will also pack more closely and readily and make an adherent layer from which air can be thoroughly excluded so that uniform contact with the plate and throughout the mass of applied material is secured," and, finally, a greater and less expensive storage capacity can be obtained.

There can be little question, upon this proof, that Faure made his discovery as early as August, 1878. Scientific people at once recognized the progressive step taken, and to him was accorded the credit of an invention of extraordinary merit.

Sir William Thomson says: "I knew the Planté secondary battery prior to 1880. Faure's invention was a very great improvement on it, so great as to produce a valuable apparatus for a large practical work instead of merely an interesting and instructive scientific instrument, which Planté's secondary battery was."

It does not appear that Sir William Thomson had the Faure patent before him but he considered that "Faure's invention was the application to two plates—preferably lead plates—of a thin layer to oxide of lead mechanically applied prior to placing the plates in the battery fluid, the plates and their coatings being insoluble in the battery fluid, and the coatings becoming so altered by the charging current as to become capable of yielding a reverse current, and this over and over again an indefinite number of times. I consider the novelty of Faure's invention to be the application of the oxide of lead to the lead plates before passing an electric current through them and the rendering of these coatings active by immersing them in the battery liquid and passing the charging current through them."

The Court here quotes from the testimony of the experts of both the complainants and defendants to much the same purport as the above, and continues:—

The inventor himself says of his earliest experiments:—"I took two plates of lead about two and a half inches wide, covered each plate on one side with a paste of litharge, etc. * * * * I do not claim to have invented spongy lead, but I boast of being the first that produced it in large quantity on the electrode of a battery, and the first to recognize it as an efficient element of a secondary battery."

It is, then, established with reasonable certainty that the discovery of a mechanically applied layer of lead, or like substance, insoluble in the electrolyte and placed upon the supports in the form of a paste, paint, or cement prior to their immersion in the battery fluid, so as instantly to become porous and capable of receiving and discharging electricity, was one of great merit. There is no doubt either that Faure was the first to make this discovery. Can he hold the fruits of his genius, or must the Court decide that in attempting, through mistake or ignorance of what had previously been accomplished, to grasp more than he was fairly entitled to he has lost what actually belonged to him? Believing that Faure is an inventor of more than usual merit, it can readily be inferred that the Court enters upon this inquiry with every disposition to give him the benefit of his actual invention, if possible to do so under the law.

The proof establishes two propositions with equal clearness. First, Faure was the inventor of a secondary battery electrode coated in the manner stated; and, second, he was not the inventor of an electrode otherwise coated.

If, by means of a disclaimer, the patent can be restricted to the actual invention this course should, in fairness, be adopted.

Section 4,922 of the Revised Statutes provides that—

Whenever, through inadvertence, accident or mistake and without any willful default or intent to defraud or mislead the public, a patentee has, in his specification, claimed to be the original and first inventor or discoverer of any material or substantial part of the thing patented, of which he was not the original and first inventor or discoverer, every such patentee, his executors, * * * * and assigns * * * * may maintain a suit at law or in equity, for the infringement of any part thereof, which was *bona fide* his own, if it is a material and substantial part of the thing patented and definitely distinguished from the parts claimed without right, notwithstanding the specifications may embrace more than that of which the patentee was the first inventor or discoverer. But in every case in which a judgment or decree shall be rendered for the plaintiff no costs shall be recovered unless the proper disclaimer has been entered at the Patent Office before the commencement of the suit. But no patentee shall be entitled to the benefits of this section if he has unreasonably neglected or delayed to enter a disclaimer.

Section 4,917 provides as follows:—

Whenever, through inadvertence, accident or mistake, and without any fraudulent or deceptive intention, a patentee has claimed more than that of which he was the original or first inventor or discoverer, his patent shall be valid for all that part which is truly and justly his own, provided the same is a material or substantial part of the thing patented, and any such patentee, his heirs or assigns, * * * * may on payment of the fee required by law make disclaimer of such parts of the thing patented as he shall not choose to claim or to hold by virtue of the patent or assignment, stating therein the extent of his interests in such patent. Such disclaimer shall be in writing, * * * * and it shall thereafter be considered as part of the original specification. * * * * But no such disclaimer shall affect any action pending at the time of its being filed, except so far as may relate to the question of unreasonable neglect or delay in filing it.

Mr. Walker, in his work on patents, at Sec. 193, has blended these two sections in one comprehensive and perspicuous explanation. He says (Sec. 194 *et seq.*): "The primary fact which brings the law into play is the claiming by a patentee of materially more than that of which he was the first inventor. Such errors may spring from inadvertence. That is to say, they may spring from failure on the part of the writer of the claims to exercise proper care in penning them. So, also, they may arise from accident, from chances against which even diligent care cannot always guard. But mistake is the most common source of such errors, and such errors may arise from mistake of fact or from mistake of law. * * * * If the patentee is willing to eliminate from his claims, everything which later information shows had been invented before him, he ought to be allowed to retain his exclusive right to the residue. * * * * There are cases where two or more inventions are covered by one claim, and in such cases a disclaimer may be made to expunge one of those inventions from that claim without disturbing the others."

Mr. Curtis says: "Specifications may also be amended by another process, that of filing a disclaimer, whenever, through inadvertency, accident or mistake the original claim was too broad, claiming more than that of which the patentee was the original or first inventor, provided some material and substantial part of the thing patented is justly and truly his own. * * * * In Seed *vs.* Higgins (8 Ell. & Blackf., 755, 771) the patentee * * * * entered a disclaimer, declaring 'For the reasons aforesaid, I do hereby disclaim all application of the law or principle of centrifugal force as being part of my invention or comprised in my claim, except only the application of centrifugal force by means of a weight acting upon a presser, so as to cause it to press against the bobbin, as described in said specification.' It was held by the Court of Queen's Bench, and affirmed by the Exchequer Chamber, that this disclaimer was valid, and that the general specification being read in connection with it, the result was a claim for only the machine particularly described." (Curtis on Patents, Secs. 286, 287.)

Judge Coxe cites the following cases:—

Aiken *vs.* Dolan, 3 Fish, 197.
Meyers *vs.* Frame, 8 Blatchf., 446.
Taylor *vs.* Archer, 8 Blatchf., 315.

(A disclaimer, filed *pendente lite* of part of the claim, was held to be valid.)

Tuck *vs.* Bramhill, 6 Blatchf., 95.
Schillinger *vs.* Gunther, 17 Blatchf., 66.
Roemer *vs.* Newman, 26 Fed. Rep., 102.
Libby *vs.* Glass Co., 26 Fed. Rep., 757.
Silsby *vs.* Foote, 20 How., 386.
Hall *vs.* Wiles, 2 Blatchf., 194, 198.
O'Reilly *vs.* Morse, 15 How., 62, 121.
McCormick *vs.* Seymour, 3 Blatchf., 209, 222.
Seymour *vs.* McCormick, 19 How., 96, 106.
Singer *vs.* Walmsley, 1 Fish., 558, 574.
Terry Clock Co. *vs.* New Haven Clock Co., 4 Ban. & A., 121.
Christman *vs.* Rumsey, 17 Blatch., 148, 160.
Coburn *vs.* Schroeder, 19 Blatchf., 377, 380.
Burdett *vs.* Estey, 19 Blatchf., 1, 7.
Atwater Co. *vs.* Beecher Co., 8 Fed. Rep., 608, 610.
Tyler *vs.* Galloway, 20 Blatchf., 445, 447.
Gage *vs.* Herring, 107 U. S., 640, 646.
Brush *vs.* Condit, 22 Blatchf., 246, 254.
Matthews *vs.* Spangenberg, 20 Blatchf., 482.
Sessions *vs.* Romadka, 21 Fed. Rep. 124.
Dunbar *vs.* Meyers, 94 U. S., 187.
Union Met. Cat. Co. *vs.* U. S. Cat. Co., 112 U. S., 624.

The law, as established by the foregoing authorities, permits the complainant to save what was really Faure's invention. The defendants, in opposition to this view, rely upon Hailes *vs.* Albany Stove Co., 16 Fed. Rep., 242, affirmed 123 U. S., 582.

There seems to be a clear distinction between that case and the one at bar. In that case there was nothing in the specification to indicate to the public that the invention of the patentee was what he sought to make it by the disclaimer. He claimed "a perforated fire pot," etc., and when he found that this was old he sought by disclaimer to limit his invention to a particular kind of fire pot described for the first time in the disclaimer. At page 587 the Supreme Court say: "A disclaimer is usually and properly employed for the surrender of a separate claim in a patent, or some other distinct and separable matter, which can be excinded without mutilating or changing what is left standing. Perhaps it may be used to limit a claim to a particular class of objects, or even to change the form of a claim which is too broad in its terms, but certainly it cannot be used to change the character of the invention. And if it requires an amended specification or supplemental description to make an altered claim intelligible or relevant, while it may possibly present a case for a surrender and reissue, it is clearly not adapted to a disclaimer. A man cannot, by merely filing a paper drawn up by his solicitor, make to himself a new patent, or one for a different invention from that which he has described in his specification. That is what has been attempted in this case. There is no word or hint in the patent that the invention claimed was a firepot with sides grated only half way, or part of the way, from the bottom towards the

top, or that such partially grated sides have any advantage over those grated all the way to the top. The first claim as modified by the disclaimer has nothing in the specification to stand upon, nothing to explain it, nothing to furnish a reason for it."

The decision states no new law, it is entirely in line with the other authorities cited. Instead of forbidding it would seem to sanction a disclaimer in the case at bar. The facts here and in the Hailes case are wholly different. Hardly one of the criticisms upon that disclaimer would apply to a properly drawn disclaimer here.

The part of the invention which, *bona fide*, belongs to Faure is an electrode in a secondary battery consisting of a support coated with an insoluble layer of active material in the form of a paint, paste or cement so as to be or become instantly spongy, etc. It was this that the scientific world recognized as a great discovery of great merit and importance. It was this that the distinguished Scotch electrician regarded as "marvelous." And this was the result of Faure's genius. No one anticipated him. It is honestly his. What he did not invent was an electrode in a secondary battery coated with a soluble layer of active material, neither did he invent an electrode on which the active material is applied by "galvanic action or chemical precipitation, or otherwise." The claim is broad enough to cover all these forms probably, and some of them certainly. What he is not fairly entitled to he wishes to give up, and keep what is certainly his own. He does not seek to broaden his patent, but greatly to restrict it. No one will infringe unless he constructs his battery in the one way to which the patent will be confined. This is the patentee's way, and it has many distinguishing characteristics which differentiate it from the ways pointed out by others. The matter to be relinquished is distinct and separate and can be exscinded without mutilating what is left. No amendment is necessary. The claim read in the light of the description is too broad. It is sought to limit it. The disclaimer suggested will not make a new patent or a different invention. The invention is fully described in the specification, and the limited claim will stand on that description.

After giving the subject the most careful consideration it is thought that Faure was the originator of the invention just described, and that it would be unjust to him to declare the patent wholly void if he is willing to restrict it to what is lawfully his own.

The fourth claim of the Faure patent (which the Court deems to be for a combination containing the following elements: *First*—A secondary battery; *Second*—A series of cells; *Third*—In each cell a pair of electrodes with an active spongy layer thereon; *Fourth*—Non-porous partitions between adjacent cells) is held not to bear a construction broad enough to cover the batteries of the defendant. In its broad sense the claim is held to be invalid for want of novelty. The mere adaptation of a well-known method of cell division to a storage battery is not regarded as an invention. In closing this part of the case Judge Coxe says:—

His invention was for a new electrode in a secondary battery. This he is entitled to, but he is not entitled to claim as new a well-known construction of cells because he puts his new electrodes into them. It is clear that a construction of the claim which is broad enough to cover the defendants' battery renders the claim invalid.

Bush *vs.* Fox, 28 Law and Eq. Rep. 1.
Holmes *vs.* The Electric Company, 33 Fed. Rep. 254.
Hailes *vs.* Stove Co., 123 U. S. 586.
Heating Co. *vs.* Burtis, 121 U. S. 296.
Railroad *vs.* Truck Co., 110 U. S. 490.
Boudoir Car Co. *vs.* Monarch Car Co., 34 Fed. Rep. 130.

A limited construction can, however, be given the claim which will render it valid. The defendants' expert insists that the claim must be confined to a combination in which the electrodes are combined with non-porous partitions between adjacent cells by being applied thereto. The manner in which this is done is described in the specification. It says: "Figure 6 is cross-section of an electrode with non-porous partition, having the prepared plates secured on both sides, and adapted for use in a battery with series of adjacent cells. * * * * It shows the arrangement of parallel plates formed with an interposed wooden board, *x*. This arrangement permits of employing thin sheets of lead, while securing at the same time sufficient stiffness, and affording means of firmly securing the parts, *x*, without any leakage between the adjacent cells formed on each side of the leaden plate *a*." The specification further states that when the supporting plates are to be placed either parallel or in any other position permitting of their being distorted by mechanical strain, stiffness may be imparted by applying them on wood or hard rubber non-porous boards so as to prevent any liquid passing from one cell to another. The boards of these compound supports have edges fitted with India rubber in order to render the cells perfectly liquid tight.

It is argued with force and plausibility that it was the intention of the patentee, as shown by these extracts from the specification, to cover only his special construction, the novel feature of which is the non-porous partition with which the electrodes are combined and to which they are applied. It is asserted that this intention is rendered more certain by an examination of the file wrapper where it is still more clearly disclosed, and that nowhere in the specification is there a description of the apparatus as constructed by the defendants. In view of these facts and because the patentee, in effect, disclaimed the construction sought to be placed upon the claim by the complainant, it would seem that the defendants' construction has much in reason and authority to support it and is the more rational of the two.

So construed the defendants do not infringe the claim.

The patent granted to Joseph Wilson Swan, February 17, 1885, No. 312,599, is for an improvement in secondary batteries. The application was filed January 18, 1882. The object and aim of the patentee was the production of plates having surfaces more suitable for holding the active material. In carrying out this idea he prepares plates with perforations, cells or holes extending through the plates, in which the active material is packed. He says: "It should be understood that the form of the cells may be greatly varied without departing from the principle of my said invention, the object being to obtain an interstitial construction of plate capable of affording a very large amount of active surface in a small compass, and to prevent the coating of oxide or spongy lead from falling away from the plate, as it would from a plain vertical surface, unless held in position by some material external to the said coating."

The claim is:—

A perforated or cellular plate for secondary batteries having the perforations or cells extending through the plate and the active material, or material to become active, packed in the said perforations or cells, substantially as described.

The specification states that the patentee has obtained a patent in Great Britain for the same invention, dated May 24, 1881. It is argued that this allegation carried the invention back to the date of that patent although the patent itself has not been introduced in evidence. No authority is produced to sustain this contention. Being a mere declaration, unsupported by proof, it is thought that it cannot be accepted as the date of the invention, which, in the absence of other proof, must be taken as of the date of the application, January 18, 1882.

The court here quotes Sir Wm. Thomson and the experts on both sides, as to the value of perforated electrodes for storage batteries, and says:—

In view of these facts there is no difficulty in deciding that an electrode so constructed was patentable. The invention is a simple one, but something more than mechanical skill was required. * * * *

The question, therefore, is whether there is anything in the art prior to January 18th, 1882, which anticipates the claim or renders it invalid.

The English patent, granted to John S. Sellon, does not anticipate for the reason that though dated September 10th, 1881, it was not sealed until March 10th, 1882, after the filing of Swan's application. It was not made patent to the public, therefore, until March 10th, 1882.

Smith *vs.* Goodyear, 93 U. S., 486–498.
Bliss *vs.* Merrill, 33 Fed. Rep., 39, 40.
Siemens *vs.* Sellers, 123, U. S., 276–283.

But the evidence of Professor Asahel K. Eaton, if it does not amount to a complete anticipation, so narrows the field of invention that nothing remains of which to predicate patentable novelty. It is thought, however, that as to some of the electrodes made by him there can be no doubt that they fully anticipate Swan's claim. If made now for the first time they would infringe, being made before the application, they anticipate.

Cook *vs.* Sandusky Tool Co., 4 Sup. Ct. R., 4.
Peters *vs.* Active Mfg. Co., 21 Fed. Rep., 319; affirmed Sup. Ct., Mch. 5, 1889.

Professor Eaton testifies that in 1881, and certainly prior to August, 1881, he made experiments in secondary batteries using perforated lead plates for the electrodes. He finally adopted them, considering them preferable to others tried by him. These plates were perforated by means of a belt punch, which cut out small discs varying from a quarter to five-eighths of an inch, according to the size of the plates. Lead sponge previously prepared was then precipitated upon both sides of the plate so as to cover both surfaces and fill the perforations. He says: "I afterwards adopted one of the methods which I had tried where I used two perforated plates with the sponge deposited upon one or both of them and the two plates put together so as to retain the sponge between them, the sponge filling the perforations. This made one electrode. The other electrode was made with two similar perforated plates, the peroxide being made into a paste with sulphuric acid and water and pasted upon each side of a piece of asbestos. This was put between the two perforated plates and pressed down so that the paste covered the whole surface of each half plate and filled the perforations. Some of these plates were perforated so as to leave a burr projecting in one direction, which aided in the

retention of the paste, the two burred surfaces being outside. This provided an enlarged cellular cavity."

In July, 1881, he made another battery with the assistance of one George Farrington, who corroborates him in part as to its construction. This battery was made by spreading the described paste upon either cloth or asbestos and enclosing it between two perforated plates of lead. The perforations, in the absence of a proper tool, were made with a knife. This formed one element. The other element was made by precipitating lead sponge upon one surface of a similarly prepared plate and covering it with another plate, so as to make one, folded together at the edge. The paste was minium mixed with sulphuric acid and water. This paste filled the perforations in the plates.

Professor Eaton also made electrodes by coating with a similar paste a frame work of woven lead wire. The batteries thus constructed by him were charged and worked successfully. Besides Farrington he is corroborated by Mr. Sleeper, who assisted in the construction of the batteries of August 1881, by punching holes in regular order in the leaden plates. And Sleeper is, in turn, corroborated by entries made at the time in his diary, which also contains rough drawings of the perforated leaden plates. No evidence is offered by the complainant which at all conflicts with the verity of these statements. As before observed, the Court is not permitted to reject the evidence of unimpeached and respectable witnesses, when they are corroborated, and there is nothing to cast a doubt upon the truth of their statements. Upon this evidence, therefore, the first Swan patent must be declared invalid.

The second patent granted to Joseph Wilson Swan is dated May 26, 1885, No. 318,828. The application was filed May 3, 1883. The claim is as follows :—

"In a battery plate or electrode composed of a conducting support combined with active material, the support in the form of a plate with angular or equivalent holes, cells or perforations extending through the same, and separated from one another by webs, walls or partitions of uniform cross-section, the active material being placed in said holes, cells or perforations, substantially as set forth."

This would seem to be for the same subject-matter covered by the first patent of Swan. It is conceded that the alleged invention is described and shown in the first patent. The only difference suggested is that the second patent is for a more limited sub-division of the same general invention. The patent in the specification states :—

"It should be observed that I do not claim herein, broadly the use of plates provided with holes or perforations extending through the same, and having the active material, or material to become active, held in such holes or perforations, as this forms the subject-matter of patent granted to me on the 17th day of February, 1885, numbered 312,599."

One of the complainants' experts after stating his understanding of the first patent says of the patent in hand : "It has a specific claim, a claim rendered specific by its limitation to uniform webs, walls or partitions separating the perforations from each other." Another of the complainants' experts says that his understanding is that the second patent covers plates or electrodes such as are described in the first patent, "with the additional limitation that the webs, walls or partitions between the cells shall be of substantially uniform cross-section."

It will be observed that the drawing of the first patent shows a plate made in exact accordance with this limitation, and the specification states that the form of the cells may be greatly varied without departing from the principle of the invention. Even if the second patent can be distinguished from the first in the particular stated by the experts it is entirely clear that the difference pointed out is wholly insufficient to sustain invention. After the first patent there was absolutely no room for the second patent ; which, upon the most favorable construction for the complaint, simply claims an arrangement which any one who had sense enough to make the perforations at all would most certainly adopt. When a patent has been granted for a plate containing rows of holes another patent cannot be granted for the same plate containing *uniform* rows of holes. Neither can there be anything patentable in the mere shape of the holes. A patent for a device containing round holes will preclude a subsequent patent for the same device with square or triangular holes. Bung Mf'g Co. *vs*, Bung & B. Co., 31 Fed. Rep., 76, 79.

Especially is this so when the applicant is confronted with his own express declarations that the shape is wholly immaterial.

It is not necessary to consider whether a valid patent can be obtained for an invention described, but not claimed, by the applicant, in a prior patent issued to him ; the application for the second patent being filed before the first patent issues. That is not this case. Swan describes no invention in the first patent which is not covered by the claim of that patent. What is not claimed is not patentable.

It follows, therefore, that the complainant, upon filing a disclaimer, limiting the first claim of the Faure patent to an electrode of a secondary battery to which the active layer is applied in the form of a paint, paste or cement, insoluble in the electrolytic liquid, is entitled to a decree for an injunction and an accounting upon the claim as thus limited, but without costs.

ANNULMENT OF THE EDISON LAMP PATENT IN CANADA.

DECISION FILED FEBY. 26, 1889.

Before the Deputy Commissioner of Patents.

The Royal Electric Co., of Canada, petitioners, and Edison Electric Light Co., respondents.

Messieurs Lash, Q. C., of Toronto ; McGibbon, of Montreal ; Curtis, of New York ; and Kerr, of Pittsburgh, Pa., counsel for petitioners.

Messieurs Hector Cameron, Q. C., of Toronto ; MacMaster, Q. C., of Montreal ; and Dyer, of New York, counsel for respondents.

ABSTRACT.

This is a Petition to the Minister of Agriculture, bearing date May 1, 1888, to have declared null and void the patent No. 10,654, granted to Thomas Alva Edison, on Nov. 17, 1879, "for new and useful improvements on electric lamps, and in the method of manufacturing the same, the title whereof is *Edison Electric Lamp*," on the ground of violation of *The Patent Act*, Consolidated Statutes of Canada, Chapter 61, Sec. 37.* On Nov. 16, 1881, an extension of three months' time within which to manufacture was granted to the patentee, on his application to this effect, in which he alleged that, "having been engaged in introducing his invention in other countries, he had failed in manufacturing in Canada, within the two years prescribed by law, owing to the large capital which is necessary to establish such manufacture."

By assignment the respondents became the holders of the patent.

The petition alleged that the patentee and his assignees had not manufactured the invention within the two years prescribed by law, and that the alleged extension of three months within which to do so had been obtained by false and willful misrepresentation ; that the patentee and his assignees had imported the invention into Canada after the twelve months allowed by law, and prayed, for these reasons, that the patent be declared null and void, and the extension above mentioned set aside and canceled.

On the application of the petitioners, the Deputy Commissioner issued an order upon the respondents' counsel to produce at the trial all the invoices, accounts, letters and other documents, enumerated in a certain paper, or "Notice to produce," previously served upon them, at the instance of the petitioners, in order that the same might be used as evidence if required.

By mutual consent, the trial was fixed for Nov. 13, when the respective counsel, with the witnesses being present, the case was proceeded with.

The respondents' counsel, in addition to the general denial, by way of preliminary plea, took exception to the jurisdiction of this tribunal, on the ground, that on March 31 last, and prior to the date of this petition, the respondents had taken action against the petitioners, in the Superior Court for Lower Canada, at Montreal, praying for damages, and the issue of an injunction, for infringement of the patent now in question ; that the petitioners did not answer the action, but on May 18, applied for a stay of proceedings in the action, until the decision on this petition could be obtained, and which application the court had granted.

The Commissioner here recounts the arguments presented on the question of jurisdiction, including citations and references, to sections 33 and 37 of the Patent Act, and a number of precedents, viz., The Bell Telephone Cases ; Smith *vs.* Goldie, Supreme Court Reports, vol. 9, p. 46 ; Mitchell *vs.* The Hancock Inspirator Co., and others.

The Deputy Commissioner stated, that in view of the large number of witnesses present from the United States, and other

*SEC. 37. Every patent granted, under this Act, shall be subject and be expressed to be subject to the condition that such patent and all the rights and privileges thereby granted shall cease and determine, and that the patent shall be null and void at the end of two years from the date thereof, unless the patentee or his legal representatives, within that period, commence, and, after such commencement, continuously carry on in Canada the construction or manufacture of the invention patented, in such manner that any person desiring to use it may obtain it, or cause it to be made for him, at a reasonable price, at some manufactory or establishment for making or constructing it in Canada,—and that such patent shall be void if, after the expiration of twelve months from the granting thereof, the patentee or his legal representatives or his assignee for the whole or a part of his interest in the patent, imports or causes to be imported into Canada, the invention for which the patent is granted ; and if any dispute arises as to whether a patent has or has not become null and void under the provisions of this section, such dispute shall be decided by the Minister or the deputy of the Minister of Agriculture, whose decision in the matter shall be final.

2. Whenever a patentee has been unable to carry on the construction or manufacture of his invention within the two years hereinbefore mentioned, the commissioner may, at any time not more than three months before the expiration of that term, grant to the patentee an extension of the term of two years on his proving to the satisfaction of the commissioner that he was, for reasons beyond his control, prevented from complying with the above condition.

3. The commissioner may grant to the patentee, or to his legal representatives or assignee for the whole or any part of the patent, an extension for a further term not exceeding one year, beyond the twelve months limited by this section, during which he may import or cause to be imported into Canada the invention for which the patent is granted, if the patentee or his legal representatives, or assignee for the whole or any part of the patent, show cause satisfactory to the commissioner, to warrant the granting of such extension ; but no extension shall be granted unless application is made to the commissioner at some time within three months before the expiring of the twelve months aforesaid, or of any extension thereof.

places distant from Ottawa, who were naturally anxious to return to their homes as soon as possible, he would not delay the proceedings at this stage, but would render his decision on this point, when judgment should be rendered on the merits of the case.

The evidence was then proceeded with, lasting over three days, including an admission of facts by the parties, when the case, by agreement, was postponed to the 17th December, for argument of counsel, when the case was ably argued, at great length, by counsel on both sides.

The evidence adduced by the petitioners established in substance: That the patent was granted to Thomas A. Edison on the 17th November, 1879; that on the 16th November, 1881, an extension of three months' time within which to manufacture was granted; that on the 12th February, 1880, Edison assigned the patent to "The Edison Electric Light Co.," and on the 30th December, 1886, the latter assigned to "The Edison Electric Light Co."—the respondents. The lamp consists of a glass globe or bulb, glass tubing, inside pieces of glass, platinum and copper wires, carbon filament and brass bottoms; all these articles were imported from the United States, from the time the patentee and his assignees began to make the lamps in Canada, and still continue to be imported; that the process of making the lamp from these imported articles consisted of several operations, such as attaching the carbon filaments to the leading-in wires—the leading-in wires having been previously let into the glass and sealed in; the glass bulb and tube attached to it, the air exhausted from the bulb, and connection made with the brass cap or base to attach it to the socket, to connect with the circuit, supplying the electric current. On the 14th November, 1881, The *Edison Electric Light Co.* started a small factory in Montreal, worked by two men, and the outfit consisted of a small dynamo, several pumps for producing the vacuum in the globes, several small glass blowers' fires, gas fires, altogether of the value of about $2,000, and commenced the manufacture of the lamps from the materials imported from the United States as above stated: and on the 17th had completed two lamps; the carbon filaments were put into the lamps in the condition they were brought in from the United States, and were not subjected to any further treatment or process of carbonization after their arrival in the factory in Montreal. The carbon filaments are made of bamboo, imported into the United States from Japan, in the crude or natural state, in strips, and on arrival at the factory in the United States, they are further split into smaller strips, the pith removed, and then by knives or dies, further reduced to the proper size of the filament; these filaments were then put on a block or mould packed with carbon, then put into a furnace and baked or carbonized; this process requires great skill and labor, and is very difficult, and can only be done by skilled workmen; they tried to carbonize the filaments in Montreal, but could not succeed, as the men were not skilled in the work. The glass bulbs were made in the United States from pot glass, the glass blowers there blowing them by several processes into the size and shape required. These bulbs were made expressly for use on the incandescent lamps, and must have the same expansion as the platinum, and are not ordinary articles of commerce; the glass tubing also must be made from the same quality of pot glass as the bulbs, so as to have the same expansion; the platinum wire also was specially prepared in the United States for use in the lamps. The employés were instructed not to sell the lamps to any who did not use the Edison dynamos or plant, and they accordingly did not so sell them, and refused to sell to any not using the Edison plant; that it was the policy of the company to do this, as the sale of the plant was more profitable than the sale of the lamps, the proportion being that where 800 lights were installed the total price was $12,000, while the cost of the lamps at $1 each was only $800, and this had practically the effect of creating a monopoly for the Edison plant. The first sale of lamps in Canada was made to the *Canada Cotton Co.*, at Montreal, in December, 1882. The capital stock of "*The Edison Electric Light Co.*," in November, 1881, was $720.000 or $780,000, the par value of the shares being $100, but they were then quoted and selling at from $1,000 to $1,200 per share, or a premium of $1,000 to $1,100 above par. In January, 1883, the factory in Montreal was closed, and the business transferred to Hamilton, and there increased and more men employed, but there was no change in the manner of getting out the lamps; the same articles were imported, but in larger quantities, the same steps of assembling all the parts and putting them together to complete the lamp were gone through at Hamilton, as in Montreal; at this time there were 3,800 lamps in use in Canada, and the annual output was from 8,000 to 10,000 lamps, and was gradually increasing; the proportionate cost of labor bestowed in the United States on the articles sent into Canada, to be used in the making of the lamps, is $32.50 on every 100 lamps made; while the proportion of the cost of labor bestowed on the lamps in Canada, after the importation of the articles composing it, is $21.80 per $100 worth of lamps made.

The respondents admitted the importation of the glass bulbs, the glass tubing, the platinum and copper wires, and the carbon filament, and that the importation continues still, and the evidence they adduced went to show that these were all raw material; that they were all ordinary articles of commerce, and could be used for any other purpose besides incandescent lamps; that the carbon filaments, as imported, were only partly manufactured in the United States, and the carbonization was completed in the Canadian factory, by the passing of an electric current through them while a high vacuum was maintained in the lamp bulbs, thereby reducing them to a pure carbon, and that this process of final carbonization was necessary to make a serviceable commercial lamp; that the glass bulbs and tubes, after they were imported, passed through several processes in the factory in Canada, to render them fit for use in the lamp; that the platinum was obtained in the United States, and before being sent into Canada for use in the lamps, was re-melted from the crude material, and then drawn out into wire, and slightly alloyed with iridium, so as to make it a little harder; and the wire was attached to the carbon and fitted into the glass bulbs in Canada; that if the company had been compelled to manufacture the carbons in Canada, it would have ruined the business in Canada; that the platinum wire would have cost two hundred fold more in Canada, as it requires a special furnace to prepare it; that the cost of material in the United States, as imported into Canada, would be in the proportion of one-third, and the labor in Canada, two-thirds.

Counsel for the petitioners argued that the evidence clearly showed that the patentee and his assignees had not complied with the provisions of *The Patent Act;* that they did not commence or carry on in Canada the manufacture of the invention within the time prescribed by law, and that they had imported it after the time allowed by law, and in addition thereto had refused to sell the invention as they were bound by law to do; that they showed bad faith and no intention to comply with the law from the beginning, as they only started their factory and began making the lamps on the 14th November, 1881, a few days only before the limit prescribed by *The Patent Act;* then again it is proved that at this period, when they applied for and obtained an extension of time, within which to manufacture, on the ground or pretension of the large capital necessary to carry on the manufacture, the capital stock of the Edison Electric Light Co, the then holders of the patent, amounted to over $700,000, the par value of the shares being $100, and their market or selling price was quoted in the newspapers at $1,000 or $1,200, or a premium of from $1,000 to $1,100 above par, while it is proved that the whole capital or plant they had in Canada at this time was only $2,000; this showed their utter want of good faith, and the misrepresentation amounting to fraud, practiced upon the Minister of Agriculture, to obtain an extension of time; that they refused to sell their lamps unless in connection with their plant, thus creating a monopoly for their dynamos or plant, which they had no right to do by law, which does not authorize or justify the imposing of conditions or restrictions upon the purchaser, as to the use of the invention when purchased by him; that the subsequent process of carbonizing the filament, after it was put into the globe and subjected to the passage of an electric current while a high vacuum was maintained, was no part of the patent, and could not be claimed for it; that the labor expended in the United States upon the articles before they were imported into Canada amounted, on the 66,500 lamps proved to have been made up to the present time, according to the proportions of cost proved, would amount to $30,000, which was so much loss to the Canadian laborer; and the manufacture of those lamps was increasing from year to year.

For the respondents it was contended that the patentee and his assignees had in every respect complied with the terms of *The Patent Act;* that they had commenced the manufacture within the time prescribed by the act, and had only imported the component parts of the lamp in the raw state or as raw material and ordinary articles of commerce; that there was no absolute proof that they had refused to sell except in connection with the Edison plant, and even if this were proved, it was no violation of the act, as the law did not, and could not, reasonably be construed to compel them to sell their lamps to opposition companies, who would run them on the arc or other plant not suited to the Edison incandescent lamp, and thereby injure or destroy the reputation of the lamp; they were always willing and ready to sell to those who would do justice to the lamp, and act fairly and honestly in giving it a fair trial; with regard to importation, it is proved that the glass globes and carbon filaments could not be made in Canada, and even if they could be made it would be at such a ruinous cost and expense that the business of manufacturing the lamps in Canada would have to be abandoned; that the law did not contemplate any such unreasonable and unjust condition as this; that in any case the importation of these articles was a small matter in comparison with the cost of labor expended on the manufacture of the lamps in Canada; that, moreover, they were merely ordinary articles of commerce, and not the invention or subject of the patent; that in two cases recently decided in the Supreme Court, and not yet reported, the *Ayer* case and the *Grinnell* case, in which the defendants were sued under the *Customs Act,* on the ground that they imported certain ingredients or articles, and afterwards assembled or put them together and manufactured an article upon which a higher duty was payable, the Custom authorities claiming that they were liable for the higher duty, the Supreme Court decided that the articles or ingredients were what they were when they crossed the boundary

line, and were not liable for the higher duty on the article into which they were manufactured after their entry into Canada; that the imported articles in the present case, could not be held to be the invention patented, and the patent could not, therefore, be declared void for contravention of *The Patent Act*.

The preliminary plea of the respondents again raises the question of the jurisdiction of this tribunal, on the ground that, by the 33d and 37th sections of *The Patent Act*, above quoted, the ordinary courts of justice have concurrent jurisdiction with the Minister of Agriculture, and the Superior Court for Lower Canada, at Montreal, having been first seized of the matter in dispute between the parties here, the petition should not and could not be entertained, the Superior Court, in which the proceedings originated, being the proper tribunal to adjudicate therein. Upon reading these two sections of the act concurrently, the meaning and intention of the law seem plain, consistent and comprehensible, and admit of the sole interpretation and conclusion, that in an action at law for infringement of a patent, the defendant may plead in defense, any fact or default which may render the patent void, and if the defense invoke the invalidity of a patent on the ground of illegal importation or non-manufacture, this must be done by pleading the only fact which, by the 37th section, establishes it—the decision of the arbiter therein specified, the Minister of Agriculture or his deputy, whose decision being final, no other tribunal can establish such fact or default. This view was held by Dr. Taché in the decisions rendered by him, and referred to at the argument, and in which he declared the jurisdiction of the Minister of Agriculture in this matter to be exclusive, and this view or finding has been sustained by all the judicial tribunals that have had occasion to refer to it. In the case of Smith *vs.* Goldie in the *Supreme Court*, the summary at the head of the report, if not to be considered as of the substance and part of the report, must assuredly be accepted as a correct and accurate interpretation thereof, contains the following words in paragraph 3: "The Minister of Agriculture or his deputy, has exclusive jurisdiction over questions of forfeiture under the 28th (now 37th) section of *The Patent Act*;" and Henry, J., in rendering judgment in the case, upon referring to Dr. Taché's decision in Barter *vs.* Smith, says: "Having well considered the case as presented before him, I would have come to the same conclusion as he did. I think the law as laid down and explained by him, in his exhaustive, and, I will add, able judgment, cannot properly by questioned. I fully concur in his conclusions, as I do also in his reasons." Again, by the Superior Court at Montreal, as reported in the *Mitchell* and *Hancock Inspirator Company* case, p. 2, where proceedings had been instituted for infringement of the patent in that court, and the special pleading was met by the demurrer to the effect that the nullity caused by violation of the 28th (now 37th) section of *The Patent Act*, cannot be tried by any other court than that of the Minister of Agriculture, upon which a stay of proceedings was asked for and granted, in order to obtain the decision of this tribunal. Again, in this present case, the Superior Court, at Montreal, has granted a stay of proceedings until the decision of this tribunal shall have been obtained on the question at issue.

I, therefore, hold that the Minister of Agriculture, or his deputy, has exclusive jurisdiction as to the question of the validity of the patent under the 37th section of *The Patent Act*, and cannot divest himself of it by relegating it to any other tribunal whatever.

Having thus disposed of the preliminary plea, I will now consider the case on its merits.

The first consideration which presents itself is, to ascertain the nature of the invention claimed by the patent, the claims of which are:—

First. "An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described, and secured to metallic wires as set forth."

Second. "The combination of carbon filaments within a receiver made entirely of glass through which the leading wires pass, and from which receiver the air is exhausted for the purposes set forth."

Third. "A coiled carbon filament or strip arranged in such a manner that only a portion of the surface of such carbon conductor shall radiate light as set forth."

Fourth. "The method herein described of securing the platina contact wires to the carbon filament and carbonizing of the whole in a closed chamber, substantially as set forth."

It is manifestly clear that the essential feature or element of the invention, as particularly described in the first and second claims is—*a carbon filament of high resistance;* this is the novelty which the inventor has contributed to the art of incandescent lighting, and it cannot be disputed by any one having the slightest acquaintance with patent law, that the carbon filament as imported by the patentee and his representatives, the respondents, and which they still continue to import, is claimed in and covered by the patent, or that any one who should use it, without the permission or consent of the respondents, would render himself liable to them in action for infringement of the patent.

The process of further carbonizing the filament after it is introduced into the bulb, by passing an electric current through it, while a high vacuum is maintained, as described by some of the witnesses for the respondents, as well as by Mr. Edison himself, is not anywhere described or claimed in the patent, and forms no part of it; on the contrary, it is the subject of another patent, obtained subsequently, by the same inventor, Mr. Edison, on the 5th of July, 1881, under the number 13,057, the fourth and fifth claims of which are as follows:—

Fourth. "The method of treating carbon conductors for electric lamps, consisting in enclosing the conductor in a glass case or globe, exhausting the air therefrom, heating the conductor by an electric current, and then hermetically sealing the glass case or globe."

Fifth. "The method of treating carbon conductors for electric lamps, consisting in enclosing the conductor in a glass globe, exhausting the air therefrom, heating the conductor by an electric current to a higher degree than that at which it is intended to ordinarily raise the conductor in use, and then hermetically sealing the glass case or globe."

Here, then, the process is fully and explicitly described and claimed, and the use or employment of it cannot be invoked or relied on by the respondents to sustain the patent now in controversy.

The next feature of importance, after the method of securing the platina contact wires to the carbon filament, as set forth in the *fourth* claim of the patent in contestation, is the glass globe or bulb referred to in the *third* claim, and it is abundantly proved and admitted by the respondents that they have always, and still continue to import these, and have never manufactured them in Canada.

Some of the witnesses for the respondents state that the carbon filaments and the glass bulbs are exceedingly difficult to manufacture, requiring great skill and judgment, and that they cannot be made in Canada, and that there is only one factory in the United States where they can be made to the satisfaction of the respondents, but this seems irreconcilable with the statement of these same witnesses in calling these articles raw material. Mr. Edison himself, in his affidavit, referring to the glass bulbs, says: "They are strictly of the character of raw material," and in view of the fact also that the records of the Patent Office show that on November 23, 1882, Mr. Edison obtained a patent for the process of manufacturing glass bulbs for incandescent lamps from pot glass. The allegation of inability to manufacture in Canada is no plea in defense of a Canadian patent, and it would be a singular misconception of the spirit of the law if a patentee, probably holding a patent for his invention in the United States, or other foreign country, should suppose he could hold to his Canadian patent, declare his inability to manufacture it in Canada, ignore the fact he was thereby preventing any one else from engaging in the industry, and defeating the very object and intention of *The Patent Act*, enacted to encourage and protect home labor and manufacture.

The bamboo cane was, and continues to be, imported from Japan into the United States, by the respondents, in its natural state, and was there by a series of manipulations or processes, reduced to a filament of required size and proportion, and was then further subjected to the very difficult and delicate process of carbonization, and in this state was imported into Canada expressly for use in the lamps.

The platinum, another component part of the invention, was, and still is, imported into the United States from Russia, by the respondents, and was there melted and alloyed with iridium, drawn into wire, and otherwise specially prepared, and then imported into Canada for use in the lamps.

I find that every essential feature, element and component part of the invention was, and still continues to be, imported into Canada by the respondents, in a manufactured state, for the especial purpose of assembling or putting them together, so as to make them an incandescent electric lamp, such as that described and claimed in the patent held by them, and now in dispute.

The two cases of *Ayer* and *Grinnell* in the *Supreme Court*, referred to at the argument, but not yet reported, do not apply to the present case, as those two suits were brought under the *Customs Act*, in virtue of which the defendants had a perfect right to import the articles separately, and if afterwards, by compounding or combining these together, they manufactured an article or commodity, of greater commercial value, subject to a higher tariff duty, they contravened no section of the *Customs Act* giving them the exclusive right to manufacture, on condition that they should not import, such as that in *The Patent Act*, which gives the inventor the exclusive right to manufacture his invention, on condition that he shall not import it; there is, therefore, no analogy between those two cases and the one now under consideration.

I, therefore, hold that the patentee and his representatives have imported into Canada since November 17, 1880, and still continue to import, the various elements and parts comprising the invention claimed in the patent No. 10,654, in a manufactured state, and that they have not at any time since the date thereof manufactured the invention in Canada.

In view of the above, I do not consider it necessary to do more than refer to the other point raised in the case—that of

refusal to sell, and even if I had to pronounce upon this point, it is more than probable I would entertain a view adverse to that ably contended for by the respondents.

Considering that the Commissioner of Patents is presumably the parent and natural protector of patents, and should extend a liberal interpretation to matters urged in their defense, consistently with a just appreciation of public interests, and in view of the importance of this case, and the large interests involved, I have bestowed upon it all the care, study and consideration which my time and ability permitted, in the endeavor to arrive at a sound, just and equitable conclusion.

I accordingly decide that the patent granted to Thomas Alva Edison, on the 17th November, 1879, under the number 10,654, for the *Edison Electric Lamp* has become null and void, under the provisions of the 37th section of *The Patent Act*.

R. POPE,
Deputy Commissioner of Patents.

Department of Agriculture,
Patent Office,
Ottawa, 26th February, 1889.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From February 19, to March 12, 1889 (inclusive).

Alarms and Signals:—*Door Spring Connection for Electric Burglar Alarms*, J. Geary, 398,144, February 19. *Electric Burglar Alarm*, L. A. McCarthy, 398,420, February 26. *Electric Signal for Engine Shafts*. J. C. Ricketson, 399, 163, March 5. *Transmitting Instrument for Electric Signaling Apparatus*, W. J. Dudley, 399,505. *Semaphore Signal*, F. Stitzel and C. Weinedel, 399,579, March 12.

Clocks:—*Electric Alarm Clock*, S. Kahan and A. W. Craven, 398,896. *Self-Winding Electric Clock*, F. W. Brainerd, 399,128, March 5.

Conductors, Insulators, Supports and Systems:—*Insulator*, W. C. Brown, 398,025, February 19. *Telegraph-Cable*, W. R. Patterson, 398,441 and 398,442. *Insulating Support, for Electric Conductors*, S. H. Short, 398,661, February 26. *Hydraulic Press for Covering Electrical Conductors with Soft Metal*, W. Siemens, 399,291. *Underground Electric Wire Conduit*, W. L. Penney and T. Little, 399,343. *Telephone Line Cable*, G. F. Shaver, 399,635, March 12.

Distribution:—*Electric Converter*, L. Gutmann, 397,910. *Equalizer for Electric Currents*, S. Bergmann, 398,121, February 19. *Regulator for Systems of Electrical Distribution*, L. B. Stillwell, 399,218. *Method of Regulation for Systems of Electrical Distribution*, same, 399,219, March 5. *System of Electrical Distribution and Conversion*, T. H. Hicks, 399,534. *System of Electrical Distribution*, G. Westinghouse, Jr., 399,639, March 12.

Dynamos and Motors:—*Alternate-Current Electric Motor*, O. B. Shallenberger, 398,457 and 398,458. *Regulator for Dynamo-Electric Machines*, E. A. Sperry, 398,668. *System of Synchronizing Electric Motors*, F. J. Patten, 398,794, February 26. *Electric Motor*, O. Lugo, 399,059. *Dynamo-Electric Machine*, W. L. Silvey, 399,068. *Regulator for Dynamo-Electric Machines*, J. F. Kester, 399,147. *Dynamo Electric-Machine*, J. H. Robertson, 399,213, March 5. *Dynamo Machine*, G. L. DuLaney, 399,320. *Dynamo Armature*, J. A. Hayes, 399,328. *Commutator for Dynamo-Electric Machines, and Electric Motors*, B. Heywood, 399,329. *Prevention of Sparking in Dynamo-Electric Machines and Electric Motors*, G. Higham, 399,401 *Prevention of Sparking in Electric Generators and Motors*, same, 399,402. *Dynamo-Electric Machine*, same, 399,403 and 399,404. *Switch for Electric Motors*, A. H. Eddy, 399,507, March 12.

Galvanic Batteries:—*Electric Battery*, E. A. Sperry, 397,945. *Electrical Battery*, W. Burnley, 397,965. *Galvanic Battery*, E. D. Cross, 397,969 and 397,132, February 19. *Mercury Holder for Battery Zincs*, W. P. Kookogey, 398,737, February 26.

Ignition:—*Electric Gas Lighter*, E. Kronenberg, 399,416, March 12.

Lamps and Appurtenances:—*Electric Lighting System*, J. A. Galvin, 397,906. *Electric-Lamp Hanger*, M. M. Wood, 397,953, February 19. *Incandescent Electric Lamp*, T. A. Edison, 398,774, February 26. *Hanger-Board for Arc Lamps*, J. J. Wood, 396,870. *Arc Lamp*, W. L. Silvey, 398,906. *Electric Arc Lamp*, same, 398,907; G. M. Lane, 399,054. *Electric Lamp Fixture and Switch*, L. W. Dillon, 399,134, March 5. *Combined Gas and Electric Light Fixture*, J. C. Cassidy, 399,497, March 12.

Measurement:—*Electric Meter*, E. F. H. H. Lauckert, 399,836, March 12.

Medical and Surgical:—*Electric Belt*, S. DeBaun, 398,133, February 19. *Couch for Applying Electrical Treatment*, J. B. Schmalz and J. B. Faulkner, 399,064, March 5.

Metal Working:—*Method of Manufacturing Screws and Bolts by Electricity*, E. Thomson, 398,912. *Electrical Welding Machine*, same, 398,913. *Electric Metal-Working and Welding Machine*, same, 398,914. *Process of Electric Welding*, C. L. Coffin, 399,019, March 5.

Miscellaneous:—*Electric Current Indicator*, W. A. Carey, 397,966. *Apparatus for Bleaching by Electrolysis*, E. Hermite, E. J. Patterson and C. F. Cooper, 398,045. *Safety Gauge*, A. F. Nagle, 398,069. *Process of Purifying Sewage by Electricity*, W. Webster, Jr., 398,101. *Static Induction Generator* E. T. Birdsall, 398,122. *Element for Thermo-Electric Batteries*, M. Mestern, 398,272. *Automaton*, A. M. Pierce, 398,276. *Switch for Electric Circuits*, C. C. Stirling, 398,288. *Stop-Mechanism for Steam Engines*, H. L. Currier, 398,314. *Electric Spray-Producing Apparatus*, H. A. H. H. DeVars, 398,327. *Electric Discharge Device*, R. Belfield, Reissue 10,986, February 19. *Electric Switch*, W. S. Hill, 398,510. F. A. Weller and A. F. Rietzel, 398,560 and 398,561. *Electric Cut-Out*, W. H. S. Wright, 398,566. *Electrical Bathing Machine*, J. W. James, 398,731. *Magnetic Regulator*, S. E. Nutting, 398,744. *Electric Circuit Coupler*, S. C. C. Currie, 398,769. *Gas Extinguisher*, A Steinhilber, 398,805, February 26. *Electric Current Regulator*, J. W. Balet, 398,926 and 398,927. *Interrupter for Electric Circuits*, I. E. Lecoultre, 399,057. *Electric Switch*, L. W. Dillon, 399,135. *Electrical Store Service Apparatus*, R. N. Dyer, 399,137. *Electric Cigar Lighting Device*, W. Tag and S. C. Smith, 399,168. *Electric Amalgamator*, J. H. Rae, 399,209. *Electric Regulator*, F. C. Wagner, 399,224, March 5. *Process of Duplicating Phonograms*, G. H. Herrington, 399,264 and 399,265. *Switch-Board*, J. W. Kelly, 399,269. *Electrical Measuring and Controlling Apparatus*, W. Siemens, 399,292. *Lightning Arrester*, C. H. Wilson, 399,305. *Coupling for Electric Circuits*, A. C. Griggs, 399,326. *Electrical Appliance for Stopping and Starting Elevators*, R. F. McFeely and H. V. Potter, 399,341. *Magnetic Separator*, J. A. Burden, 399,375. *Electric Circuit*, J. J. Carty, 399,377. *Electric Circuit Protector*, W. B. Harvey, 399,400. *Electric Switch*, H. T. Paiste, 399,550. *Coin-Operated Induction-Coil*, P. G. Williams and A. W. Roovers, 399,591. *Regulator for Electrical Machinery*, G. H. Condict, 399,599, March 12.

Railways and Appliances:—*Driving Mechanism for Cars*, F. J. Weis, 398,207, and 398,208 and 398,209. *Railway Car*, J. A Brill, 398,222. *Cable Railway System*, C. J. Van Depoele, 398,294, February 19. *Current-Collecting Device for Electric Railways*, R. M. Hunter, 398,402. *Support for Electric Railway Wires*, T. H. Brady, 398,489. *Conductor for Electric Railways*, O. Dahl, 398,498. *Electric Brake for Railway Trains*, A. H. Bowman and W. P. Widdifield, 398,577. *Electrical Railway Signal*, H. Hayden, Jr. and W. F. Z. Desant, 398,613. *Electric Railway*. S. H. Short, 398,662. *Switch Mechanism for Electric Railways*, same, 398,663, February 26. *Electrical Tramway*, H. T. Blake, 398,814. *Crossing-Conduit for Electric Railways*, I. W. Heysinger, 398,963. *Electric Railway*, H. W. Smith, 399,091. *Electric Car*, same, 399,092. *Electrical Railway Signaling Apparatus*, H. J. Palmer, 399,155. *Circuit-Closer for Railway Car Telegraphs*, G. I. Hopkins, 399,228, March 5. *Electric Railway*, J. B. Blair, 399,236. *Electric Railway Switch and Alarm*, W. S. Hull and J. C. Anderson, 399,331. *Electric Railway System*, C. S. Bradley, 399,372. *Conductor for Electric Railways*, R. M. Hunter, 399,409. *Railroad Signaling Device*, F. P. Benjamin, 399,474. *Electric Railway Signal*, T. A. B. Putnam, 399,556, March 12.

Storage Batteries:—*Secondary Battery*, J. T. Pedersen, 398,075; I. A. Timmis, 398,194, February 19. *Electrode for Secondary Batteries*, E. M. Lang, 398,409, February 26. *Secondary Battery*, E. R. Knowles, 399,052 March 5. *Secondary Battery Electrode*, A. V. Meserole, 399,274. *Secondary Battery*, J. L. Huber, 399,535, March 12.

Telegraphs:—*Telegraphy*, C. E. Dressler, 397,977. *Floating Telegraph Station*, U. Dieuleveult, 398,035, February 19. *Quadruplex Telegraphy*, C. L. Healy, 398,614. *Stock Indicator*, J. A. Enos, 398,713, February 26. *Printing Telegraph*, F. H. W. Higgins, 398,833. *Automatic Telegraphy*, J. O'Neil, 399,154, March 5. *Telegraph System*, W. Burnley, 399,314, March 12.

Telephones and Apparatus:—*Stretcher for Mechanical Telephone Line Wires*, A. W. Butterworth, 399,016. *Telephone Exchange*, W. B. Vansize; reissue 10,969, March 5.

EXPIRING PATENTS.

Patents relating to Electricity which become Public Property in March 1889.

Reported for the ELECTRICAL ENGINEER, *by* F. B. Brock, *Patent Attorney* 639 *F street, Washington, D. C.*

Electro Magnet, I. P. Tice, 125,151, April 2, 1872. *Distributing Electricity for Gas Lighting*, S. Gardiner, Jr., 125,387, April 9, 1872. *Electro-Magnetic Engine*, W. G. Thornton, 125,504. *Electro-Magnetic Watchman's Register*, W. D. Sheppard, 125,624. *Telegraph Apparatus*, G. Little, 125,582, 125,583, 125,584, 125,585, 125,586 and 125,587, *Electrical Safe Protector*, Rowell and Duncan, 125,693, April 16, 1872. *Telegraph Sounder*, M. N. Goodyear, 125,806. *Printing Telegraph*, R. H. Gallagher, 126,048, April 23, 1872. *Insulator*, J. I. Conklin, Jr., 126,027. *Insulator Fastening*, D. Doren, 126,038. *Unison Stop for Printing Telegraph*, M. F. Wessman, 125,920. *Electrical Alarm for Bank Safes*, Butler & Parmelee, 126,263. *Electrical Lining for Safes, etc.*, N. B. Guernsey, 126,289. *Electrical Torch for Lighting Gas*, W. W. Batchelder, 126,251. *Electro-Magnetic Alarm*, N. B. Guernsey, 126,287 and 126,288. *Telegraph*, N. B. Guernsey, 126,290. *Printing Telegraph*, G. B. Scott, 126,336. *Printing Telegraph*, G. M. Phelps, 126,329. *Printing Telegraph*, H. VanHoevenbergh, 126,353. *Collecting Electricity for Telegraphing, etc.*, W. H. Ward, 126,356, April 30, 1872.

[Drawings and specifications of any patent will be furnished by Mr. Brock at cost, 15 cents each.]

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VOL. VIII. NEW YORK, MAY, 1889. No. 89.

A CENTENNIAL REFLECTION.

THE electrical engineer has much more than half a hundred years to wait before he can commemorate the centennial of his art. Indeed, it would be somewhat difficult to fix upon a precise period of time when the applications of electricity to the useful arts acquired a range and magnitude sufficient to justify the use of the term "engineering" to describe their practice. Telegraphy, prior to submarine work on a large scale, scarcely called for the resources of the engineer, properly so-called; ocean telegraphy for over thirty years has demanded engineering talent of a high order; but not till the advent of electric lighting, following the successful generation of electricity in large quantities by mechanical means, did the electrician have to become in a large way an engineer. Mechanical engineering now fills quite as large a place as the proper skill of the electrician in the great electrical industries of lighting and the transmission of power.

But it is not our purpose to seek a date whose hundredth anniversary our successors of the twentieth century may celebrate as the birthday of electrical engineering; but rather to direct attention to a particular reason for a hearty participation by electricians in the centennial festivities just closing.

In orations and in the daily press the transcendent merits of the Constitution, which was finally started on its course by the inauguration of Washington as president of the United States, have been generally and adequately set forth, both on this and preceding anniversaries, and it would not be fitting in a technical journal to enlarge upon the general theme. But the Constitution contains one provision to which we may well direct notice at this time, namely, the provision for a system of patents for inventions in the useful arts.

"The Congress shall have power * * * to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

The wisdom and justice of this clause, from the section of the Constitution prescribing the powers of Congress, as disclosed in their effect upon the industrial development of the United States, signally illustrate the far seeing prudence of the framers of our organic law. It would seem that only eyes dimmed by enviousness or stinginess can fail to see that the patent system founded upon this constitutional power has been a chief factor in the marvelous growth and diversification of our industrial arts.

We would not be counted among those who extol our material prosperity and national wealth as the chief benefits to be reaped from the wise sowing of the fathers; these things are good—they are not the best fruits; but our attention is now upon a limited part of the field, and that part has borne fruit for no class of workers in "science and useful arts" in greater abundance than for electricians. Our art, scarcely dreamed of when the Constitution was written, and still so new that many men are living who saw its beginnings, has entered field after field of usefulness, and now seems likely at no distant day to enter every workshop through its latest application—the transmission of power.

Does any electrical inventor or engineer believe that all or nearly all this could have been achieved without the protection of property in invention or discovery secured through the patent system? We think not. Let us add to our participation in the general felicitation attending the Centennial of Washington's inauguration and the establishment of the government of the United States, a special recognition of the value of that provision of the Constitution upon which was based the liberal patent system which has done so much to stimulate advancement in our own and other arts.

THE WESTON SECTIONAL ARMATURE PATENT.

IT looks as if the Westinghouse Electric Co. in acquiring control, through the United States Electric Lighting Co., of the recently issued patents of Mr. Weston for sectional armatures for dynamo-electric machines—an abstract of which we print in another column—has scored a point of some importance in the general electrical situation. The history of this patent is briefly as follows: In 1882 applications were filed in the Patent Office by Thomas A. Edison and Edward Weston, the former on August 14th and the latter on September 22d, in which both parties claimed an armature made of iron plates separated by interposed insulating material and mounted on an insulated shaft. Weston, in addition to this, also claimed broadly the armature when constructed of iron plates with interposed insulating material, without reference to the shaft or the type of armature. By some oversight Edison's patent was allowed to issue prematurely on October 10th, 1882, but an interference nevertheless proceeded and was

finally terminated in regular course by a decision awarding priority of invention to Weston. The Patent Office refused meantime to issue Weston's broad claim until the interference on the specific claim was decided, and hence it has remained pending for several years. The scope of the patent, as now issued, is apparently broad enough to cover not only dynamo and motor armatures but converters as well.

The Westinghouse company, with its characteristic energy, lost no time in commencing a suit to test the validity of the patent, selecting as a defendant the Manhattan Electric Light Co., of New York city, which operates what is known as the Fort Wayne or Slattery system. The Edison Electric Light Co., it appears, were wise enough to protect themselves in season by arranging for a license under the Weston patent, so that their manufacture and sale of apparatus containing the invention will not be interfered with. Nevertheless, there must be many thousand of dynamos and motors in the United States, in which the combination claimed forms an essential feature, and which have been put on the market by other parties. The issue of this patent, by the way, indicates pretty conclusively one of the objects which the recent arrangement between the Westinghouse and United States companies was designed to accomplish. The legal situation in the immediate future is likely to become exceedingly interesting.

"HOW IT STRIKES A CONTEMPORARY."

Journalism in America, like everything else in that go-ahead part of the globe, is much afflicted with a tendency to boastfulness. True, there is, in many cases, something to boast about, but the way in which many of our otherwise estimable contemporaries in the electrical field talk about themselves, their energy, progress, and enterprise, makes us smile, sadly smile, to see such excellent, well-conducted journals depart so far from the paths of modesty. The copies latest to hand of two well-known American electrical journals, one from New York the other from Chicago, run each other very close in a bragging competition. We rather fancy Chicago scores in this particular competition, if not in the journalistic one.—*Electrical Review*, London, March 15.

The particular horn-blowing referred to in the above paragraph was merely somewhat more vociferous than the habitual tooting of some of our esteemed brethren. Their unmelodious and discordant notes seem to vary in pitch and blatancy only with the supply of wind. The persistence of the habit on the part of some highly valued exchanges is the more surprising because its indulgence is worse than unnecessary, and must, we should imagine, be offensive to such of their readers—the majority, we are sure—as are quite capable of discovering for themselves the enterprise of the editors and publishers in producing a valuable journal, and can, by the aid of simple arithmetic, or a pair of scales, even determine how much bigger than usual a particular issue may be.

One of the very best electrical journals in the country is a notorious offender, accompanying its serial tooting by a sort of drone bass, like a bagpipe, from an automatic horn (electrotyped apparently), which never stops its strident proclamation of the antiquity of the journal and its precedence of all others in entering the electrical field. The burden of this particular toot sounds oddly in the ears of those who are familiar with the course of electrical journalism in America, and particularly to such of them as occasionally look over old files and may have come across some remarks of the present principal proprietor, and recent editor-in-chief, of the journal we have in mind—who once conducted a paper of a different class—in disparagement of electrical journalism and of the prospects of two periodicals which had already entered that field ahead of his present publication. We congratulate him upon the promptness with which he discovered his mistake, and no less upon the excellence of the electrical journal which he soon afterwards began to publish and still maintains.

The timely comment of our valued London contemporary has suggested these remarks; which we make in more sorrow than anger, and solely in the interest of a more dignified tone in the electrical press. Why not try the experiment of hanging up the fish-horns for a while, brothers, and of trusting to the acumen and good sense of readers to discover your enterprise and your excellence?

AS TO THE BATE CASE.

A valued correspondent, whose letter we printed in the April number of the Electrical Engineer, criticizes the opinion editorially expressed in our issue of the preceding month, to the effect that under the doctrine announced in the Bate decision the premature termination of foreign patents through failure of the patentee to pay taxes will hereafter be likely to affect adversely a previously issued United States patent for the same invention.

Of course, our opinion must be taken for what it is worth; but to prevent misapprehension, we take occasion to state most emphatically that we regard the enactment by which the duration of a prior foreign patent is permitted to affect in any way the value or duration of the domestic patent as a relic of mediæval barbarism and a disgrace to our statute book, which ought to be summarily swept away. The Canadian statute which declares a patent void by reason of importation or non-manufacture is not a whit better; they are both of them the outcome of the absurd notion, which has survived from the dark ages, of trying to "protect" industry by interfering with it in every possible way. It is not our province as journalists to defend the statutes or the decisions, but to say what we think their effect will be likely to be under certain contingencies. It is quite true, as our correspondent contends, that the point referred to was not actually decided in the Bate case, and we are forced to admit that it would not be an unprecedented circumstance if the next time the question comes up the Supreme Court should decide it exactly contrary to the logical deduction which necessarily follows from the text of its opinion in the Bate case. The assumption of our correspondent that the action of the Supreme Court would be in the line of aiding the patentee seems to us, however, to be quite destitute of adequate foundation. A collation of the opinions rendered by it since the celebrated case of the Bridgeport Brass Co. would, on the contrary, indicate that the settled policy of the court has apparently been to decide every case adversely to the patentee, if at all possible to do so, either by declaring the patent void, or else by holding that the defendant had not infringed. We do not know that the point in question is likely to come before the Supreme

Court in the near future, and we are well aware that the situation may undergo much change before it does, but in the meantime we must say that we do not see reason for revising our original opinion.

The American Institute of Electrical Engineers will hold its annual meeting May 21st and 22d. The business meeting, for the election of officers, reception of reports and consideration of the affairs of the Institute, will be held at the house of the Society of Civil Engineers Tuesday evening, 21st. The general meeting for the hearing and discussion of professional papers will take place on Wednesday, 22d; the morning session at the house of the Society of Civil Engineers, and the afternoon session at the College of the City of New York, where electrical apparatus will be provided for experiments required in illustration of some of the papers. Before leaving the house of the Civil Engineers to attend the afternoon session the members of the Institute and their guests will partake of luncheon and enjoy an hour of social pleasure.

The papers announced for the general meeting are the following:—

"Modern Views as to the Nature of the Electric Current," with experiments, by Professor H. A. Rowland; "The Inherent Defects of Lead Storage Batteries," by Dr. Louis Duncan; "Magnetism and its Relation to Induced Electromotive Force and Current," by Professor Elihu Thomson; "The Regulation of Dynamos and Motors," by Dr. Schuyler S. Wheeler; "The Measurement of Telephonic Currents," by Professor Chas. R. Cross; "A Series of Tests on the Life and Efficiency of Incandescent Lamps," by W. H. Peirce, of the Chicago Burlington & Quincy R. R.; "Some Results with Storage Batteries in Train Lighting," by Alexander S. Brown, of the Pennsylvania R. R. These titles constitute a judicious combination of theoretical and practical topics, all closely related to contemporaneous investigation and practice. A more timely and admirable programme could not be desired.

It is hardly necessary to remind our readers that the Institute of Electrical Engineers invites and desires the presence at its meetings of all persons interested in electrical progress.

Judge Wallace's decision against the Western Union Telegraph Co. (of which we print the essential parts in other columns) seems to have had the effect of breaking the deadlock between the Board of Electrical Control and the electric companies generally. A vigorous campaign of pole chopping was immediately afterwards begun under orders of the Mayor, and it still goes on. Commissioner Gibbens appropriately headed the first attacking party, directing the movements of the axemen from the top of a lumber pile in Union square. Poles have fallen thick and fast for some weeks, and a large stock of second-hand wire and line material has fallen into the hands of the Department of Public Works. The wires removed cover a variety of electric service, but were mainly the property of the telegraph and electric lighting companies. Both these services suffered interruption or suspension. This was less serious for the telegraph company than for the electric light companies. The considerable number of people who have lost their electric light service, and the wayfarers through darkened streets, will be consoled by the reflection that they are martyrs in a great cause. No doubt the telegraph and electric lighting companies will find their inconvenience and losses alleviated by a similar reflection.

OBSERVATIONS.

Not many days ago, there was a committee hearing in the Canadian House of Commons, at Ottawa, at which one of the Honorable Members who advocated compulsory underground wire legislation turned out the following piece of logic:—"I am informed that some years since, the English courts declared that in the eye of the law, the telephone is a telegraph; therefore it is plain that the electric light also is a telegraph; and it follows, Mr. Chairman, that all electric wires are telegraph wires."

There would, however, seem to be something of a hiatus between the law and the logic of the above proposition.

. . .

Time was, when newspaper science, especially electrical science, was a thing to be scoffed at, by the initiated. But the newspaper is the mirror of the world, and electricity being now a popular fad is now constantly reflected in the said mirror. True it is, that the reflection is sometimes distorted, but that counts for nothing with the people; and it is very bad form to disagree with or to know more about one's own vocation than do the daily newspapers.

Since this is so, what happiness to realize that the electrical utterances of the daily press can now be relied upon as furnishing the latest and newest information! It is quite certain that many electricians will be both pleased and profited by ascertaining from the columns of the Boston *Globe*, that:—"The power of resistance or the unit of an ohm is equivalent to one ohm passed through one yard of mercury." It is gratifying to find that the true value of the ohm is finally determined.

The Boston *Advertiser*, not to be outdone as a science expounder then tackles the art of electrical welding, and after giving a really creditable account of the way the thing is done, says:— "The principle of this process is so simple and so direct that the wonder is nobody thought of it before. It is based on the incandescence of the carbons in the arc light."

. . .

In recent legislative hearings the allegation was made that the Western Union Telegraph Co. has for years used a potential difference of 400 volts on its lines without hurting or inconveniencing anybody; and the inference drawn or intended, was, that, therefore, an E. M. F. of 400 volts was under all circumstances innocuous when employed on electric railways and elsewhere.

Whether or no the electric railways always restrict themselves to a voltage of 400, it seems scarcely logical to arrive at a conclusion based upon incomplete premises.

From such reports as are available in this case, nothing was said of the resistance of the circuits upon which the Western Union uses such an E. M. F. and it is evident that there may be such a resistance as will reduce the current to a very low point indeed. The experience of most of us leads to the opinion, that even comparatively low electromotive forces *may* under certain conditions, and where the currents are of great volume, be dangerous; equally with currents of less volume and higher E. M. F. That is, both E. M. F. and C. must be of considerable strength before the danger element appears.

Who ever heard of the current developed in a speaking telephone hurting anybody? Yet it is incontestable that the currents generated in a telephone circuit are developed under an enormous E. M. F., because they can manifest themselves, and perform their legitimate work, in circuits in which a dozen persons taking hold of hands are included, or otherwise including great resistances.

It may be feared that the 400 volt statement, while well adapted to work upon the non-electric mind of the legislative committee-man, was a trifle dis-ingenuous.

ARTICLES.

THE THOMSON-HOUSTON ELECTRIC RAILWAY SYSTEM.

When the Thomson-Houston Electric Co. entered the field of electric railways one of their first steps was to purchase the patents owned by the Van Depoele Electric Manufacturing Co., and to secure the services of Mr. Van Depoele, the inventor of the system which bears his name, whose valuable services are still retained by them. At that time the Van Depoele company had equipped 12 railways with its system, and had taken a leading part in demonstrating the practicability and commercial success of electric traction. Mr. Van Depoele was one of the earliest workers in the application of electricity to car traction in this country; and it is not too much to say that the rapid development of electric street car service has been very largely along the lines pursued in his work. This is particularly true in respect to systems of conductors, Mr. Van Depoele having persistently adhered to the use of overhead wires, a method now employed on nearly all the roads that are in successful operation. The Thomson-Houston company did not adopt the Van Depoele system entire, but after careful study selected the best features, which, supplemented by the work of the electricians and engineers of the company, resulted in the making of a number of changes conducive to the general perfection of its railway apparatus and appliances. It was therefore determined :—

(1) To place the motors underneath the car bodies, instead of on the front platform, and to arrange them so that they would not project above the car floor, or necessitate the changing of the car body in any way.

(2) That direct gearing be used.

(3) That ordinarily each car be equipped with two motors driving the axles independently of each other, except in cases where the grades are very slight indeed, when one motor may be used.

(4) That it is not expedient to apply the motors to ordinary running gear, but that specially designed trucks should be used.

(5) That the motors be mounted on the trucks so as to be entirely independent of the car body.

Many new and valuable features of importance were added to the apparatus from time to time, resulting in continuous improvement of the system through combining the experience of the electricians of the Thomson-Houston company with that of Mr. Van Depoele. Some of these additional features will be mentioned in the description which follows. They include, in addition to the specially constructed motors, special switches for car work, fuses, lightning arresters and controlling devices.

The Thomson-Houston company has confined itself to the overhead system of conductors in its railway construction, being convinced from the results of experiment and practical experience that this was the most desirable and economical method that could be employed in present practice.

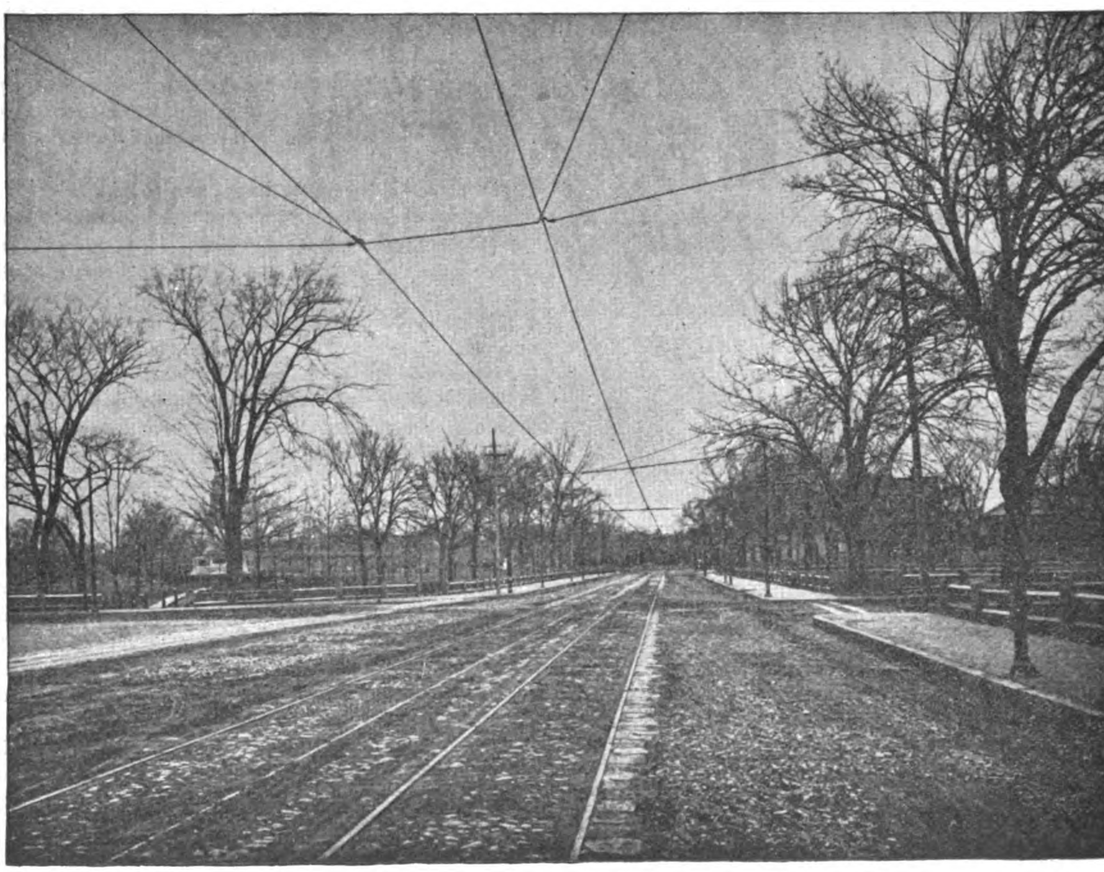

Fig. 1.—West End Street Railway, Boston, Cambridge Division.

The main conductor in most cases, therefore, consists of a stout, bare copper wire, fed with the current at any convenient point or points, and is stretched above the roadway on suitable supports, the contact to such line being made with a trolley underrunning the line.

The line construction has been of three kinds, termed cross suspension, single bracket suspension, and double bracket suspension.

In the cross suspension the main conductor is upheld by transverse cross wires, which are supported at intervals on poles on the two sides of the street. The poles are placed in pairs oppositely, and are joined by a light supporting

wire upon which the main conductor is carried through the medium of suitable suspending insulators. This construction is well illustrated by the Cambridge division of the West End Street Railway, Boston, Mass. (figure 1).

The second method, or single bracket suspension, is employed where the track is laid at the side of the street. In this case single brackets, attached at right angles to the poles and over the street, support the conductor. The line of the Omaha and Council Bluffs Railway and Bridge Company, Omaha, Neb., is a good example of this form of construction (figure 2).

The third mode of construction is used where there are double tracks near the middle of the street, and is particularly adapted to the case of a wide street. The two conductors are then suspended from double brackets placed at right angles to the tracks, projecting from poles set between them. One mile of the Eckington and Soldiers' Home Railway, Washington, D. C., is equipped in this way (figure 3).

When the line is long and the traffic very heavy, feeder wires are run out from the central station and connected to the circuits at the proper points. In all its work, especially on curves, the Thomson-Houston company has evidently planned to use as few auxiliary wires as possible. As can be seen from the roads already equipped, the overhead line is neat and unobtrusive, and much less unsightly or noticeable than such work is generally supposed to be by those who have not made an examination of the best constructed electric railways in the country.

THE TRUCK AND MOTOR FRAME.

The general plan of the Thomson-Houston company's motor truck will be readily understood by reference to the accompanying illustrations, figures 4 and 5. The motors are flexibly supported on the truck, are entirely independent of the car body, and, therefore, permit the ordinary car body, either of the open car type or the closed type, such as is used in winter, to be applied to the motor truck without the slightest alteration. The trucks themselves, therefore, as well as the different parts of the machinery are relatively interchangeable, the design being, as far as possible, to make all parts according to standard, whereby, they may be assembled without fitting. The gearing is planned for the simplest possible construction. It will readily be understood that the serviceability of motors under the harsh conditions of use in car service, running as they do at all speeds, and at all loads, will depend in a large measure upon the freedom from wear of the essential parts. The bearings, therefore, as well as the gearing require to be specially constructed to meet the extraordinarily severe conditions, and this remark applies particularly to the electrical details of the motors, such as the commutator and brushes and the field and armature winding. There is no question that in railway work the ability of the electrical engineer to overcome extraordinary difficulties has been severely taxed; but it is a characteristic of our time that the most difficult problems are quickly solved, and the electric motor as applied to traction is a case in point. When we realize the conditions under which this class of machinery must work in order to succeed, the results thus far obtained are truly surprising. There are the slush and mud of the street, the dry sand and grit blown about, the moisture of damp and rainy seasons and the splashing of water to attack the motor, in addition to the strains of starting and stopping, the running at varying speeds under the extreme variations of load, all of which necessarily combine to break down or deteriorate the apparatus, so that it may truly be said that the difficulties presented as compared with those in electric lighting or stationary motor transmission are very much greater. The electric motor itself, is of course, the vital element of the whole structure, and what would naturally be regarded as its weakest point would be its armature with its commutator and brushes. Each motor in the Thomson-Houston system

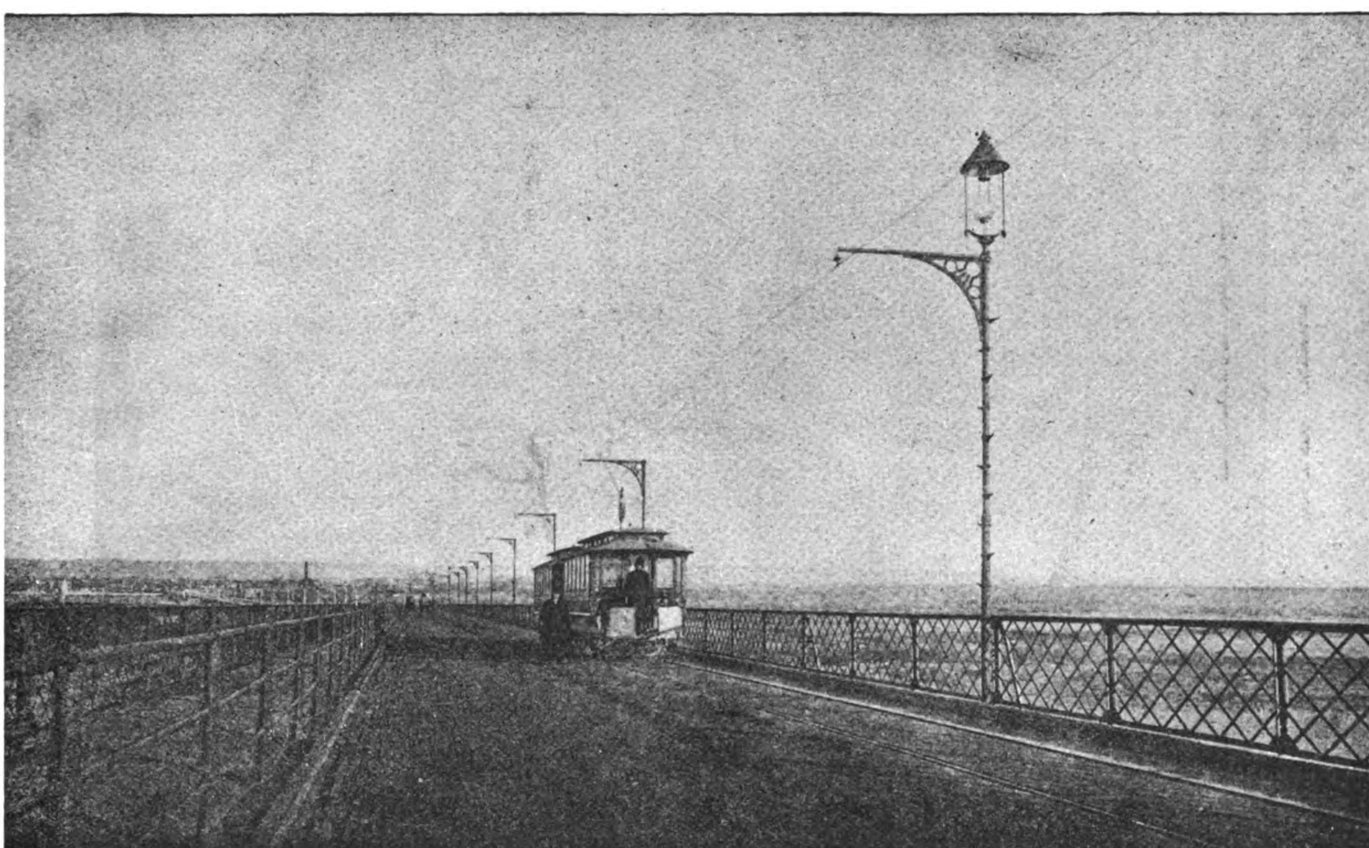

FIG. 2.—Omaha and Council Bluffs Railway and Bridge Co., Omaha, Neb.

has a single good-sized commutator with but one pair of brushes.

The brushes of the motor (see figure 8) should be specially mentioned here. The copper brush used by the Thomson-Houston company is essentially different in form and mode of application from any other. It is made of strips of copper, bound together, set at an angle to the armature shaft. It is held in place by tension springs and is always maintained at an even pressure, thus insuring evenness of wear of both brush and commutator. Its form is such that the direction of rotation of the armature can be reversed without damage or necessity for manipulation. A pair of these brushes has been in use 65 days, during which time the car covered a distance of more than 4,000 miles. Notwithstanding the excellent service of the copper brush it has been superseded by carbon, mounted in a special manner so as to secure the greatest conductivity and the several advantages which it has shown itself to possess. This improvement is due to Mr. Van Depoele who has patented it, and great credit must be given to him for his persistence in finding the conditions and construction for its best use and in overcoming the disadvantages attending the use of carbon contacts. Practice with it for a considerable time has shown it to have considerable superiority for railway work when constructed and used in accordance with Mr. Van Depoele's invention. By its use the troubles of sparking and the scoring and wear of the commutator have been greatly reduced. Favorable reports of the operation of this form of brush have been made wherever it has been tried. A pair used on the Eckington and Soldiers' Home Railway, Washington, D. C., gave a record of 41 days, during which time the car traveled 2,965 miles.

One end of the motor is hung upon the axle of the car by two large bearings, and the other end is supported by a knee fastened to the field magnet and bearing on a channel iron beam fastened at its ends to the side irons connecting the pedestals or boxes. The arrangement of the supports is such that the motor is comparatively free to swing into different positions with respect to the framing of the truck, and this enables the starting of the car, increasing the speed, or the reversal of the motor, to be made without causing undue strains on the truck frame, or the motor supports, and is particularly useful in the movement of the motor truck around curves. The bearings of the motor shaft and of the gears are all self-oiling, and are capped to protect them from the entrance of grit and dirt. The armature shaft, for example, is constructed so as to rotate while immersed in oil, so that the shaft lubricates itself continually, and by this arrangement the attention required to oil the bearings and heating of the bearings are avoided. The devices for this purpose have been found by continued use to be thoroughly well suited to the purpose for which they were designed.

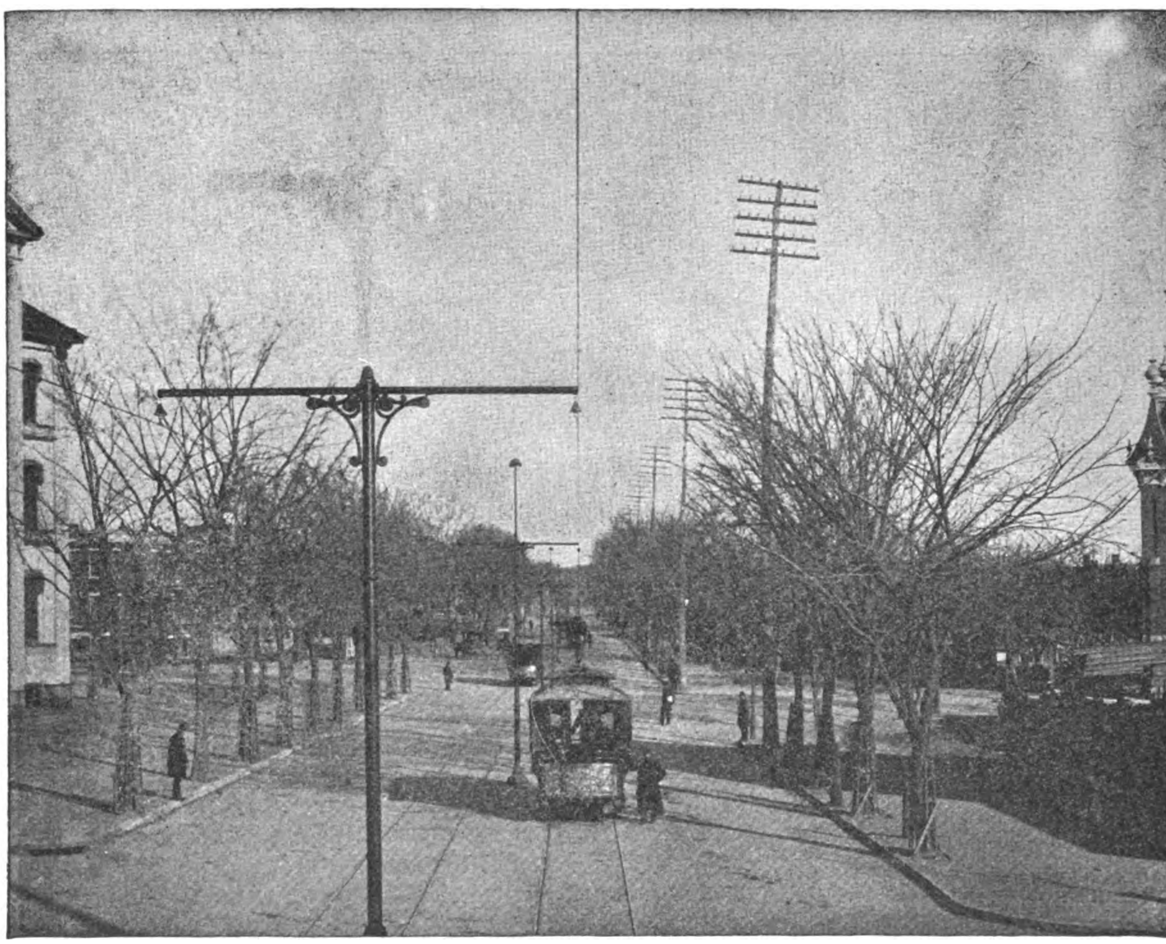

FIG. 3.—Eckington and Soldiers' Home Railway, Washington, D. C.

THE GEARS.

Only cut gears are used. The armature shaft pinion is built up of alternate discs of metal and fibrous material firmly fastened together. The intermediate gear is made of cast-iron, and is secured to a shaft having a bearing on each side of the motor frame. This preserves the parallelism of all the running shafts and prevents the possibility of the gear wearing out of line. The second pinion engages with a split gear fastened to the car axle. By this arrangement and construction of gearing much of the noise of running has been overcome, while solidity and strength are retained.

OVERHEAD CONSTRUCTION.

A single overhead conductor is the standard system, the rails being used for the return current. The structure is light and unobtrusive, and, particularly when iron poles are employed, can hardly be regarded as an obstruction or disfigurement of a city street. It is the telegraph and telephone companies with their enormous poles heavily laden with a multiplicity of wires that have evoked what public sentiment exists against overhead electric wires in general.

easy adjustment to bring the conductor directly over the track. These supports are of such shape as to hold the conductor in the plane of the cross wires, so that the transverse strain of the latter has no tendency to tip the conductor supports out of horizontal. (See detail below.) The whole arrangement at curves is light and simple, requiring but few extra cross wires, and as seen on recently constructed roads of the Thomson-Houston company, well illustrates the progress made in reliability of action as well as in simplicity and lightness.

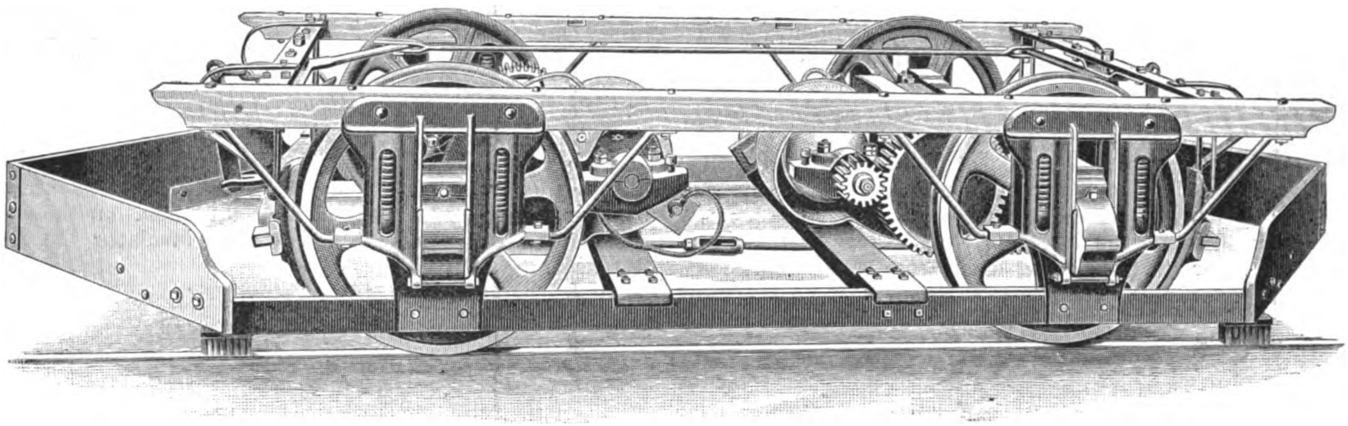

FIG. 4.—Thomson-Houston Motor Truck.

The Thomson-Houston company has done nearly all of its work with a single overhead conductor, using the rails for a return circuit, but in some cases a two-conductor system may be used.

The main conductor is supported from bracket poles on narrow streets, where the tracks are near the side of the street; or on wide avenues where poles can be placed between the tracks. In other cases the conductor is supported by cross wires reaching from pole to pole on opposite sides of the street, or from building to building where the sidewalks are narrow and permission can be obtained from the property owners to place neat and strong fastenings on the face of the buildings. Any style of pole can be used, from that ordinarily employed in telephone construction to the most ornamental form of iron pole. Poles are placed at intervals of 100 to 125 feet.

The arrangement of the overhead line at curves and turn-outs is one of the best features of this system. Light but strong metal supports are provided for the conductor, insulated from the poles, and so arranged as to permit of

On long lines the trolley wire or main conductor is reinforced by feeder wires at proper places along the line, as stated above. The feeder wires, which are run out from the power station and attached to the main conductor at suitable intervals not only serve to maintain a constant potential at all points of the line, but also to prevent a break at one point interfering with the operation of cars on other portions of the road.

Details of overhead construction are shown in the accompanying plate, figure 8. Numbers 1, 2, 3, 4 and 5 are frogs or switching boxes, used on branches, turn-outs and crossings. They are clamped fast to the underside of the wire, so that the trolley on leaving the wire enters the box on one side to come out the other, following the direction of the tracks below. At the extremity of each arm of the frog is a metal plate or tongue (see 35) soldered to the wire above and extending into the box or frog. The object of this tongue is to bring the contact wheel down below the wire sufficiently to prevent it from striking the edge of the frog as it enters the box. At the edge

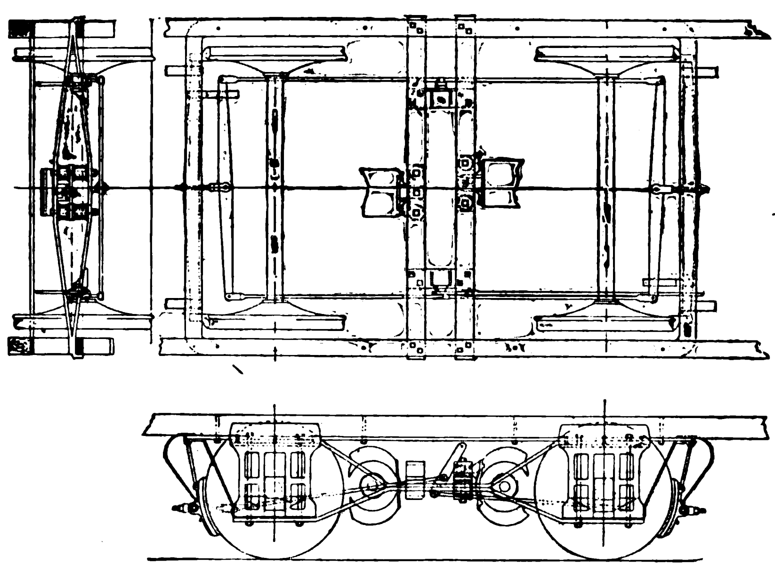

FIG. 5.—Thomson-Houston Motor Truck.

of the box the tongue is equal in depth to the depth of the groove in the contact wheel.

Number 6, is an underrunning ear, made of brass, grooved to fit the overhead conductor. The groove is turned to facilitate soldering to conductor; the upper part of the ear is provided with a projection, drilled so as to admit of suspending the ear from the insulator or bolting it to a bracket in case of a deflection in the line overhead following the track below.

Number 7, is a suspension insulator.

Number 8, is a porcelain insulator, used to improve insulation between the main conductor and the cross wire, and also to offer a large bearing surface where suspended from the cross wire. In practice, an iron wire ring of, say, number 6 galvanized iron wire is made, placed in the grooves of the insulator and closed upon it, leaving a loop at bottom to hook the suspension insulator in. This, in combination with the cone insulator (number 9), makes a very perfect insulation. The porcelain insulators are slipped on the cross wire before the latter is fastened to the poles.

Number 9, is a cone insulator, used for suspending main conductor and insulating same from cross wire. As

Number 12, insulator rod, is made of hickory turned and provided with enlarged ends bound in by a brass ferrule. Holes are drilled through this ferrule and the wood on each end; the cross wire is fastened through these holes. The insulator rod is fastened each side of the curve ear either close to the ear or close to the pole, as preferred. This insulates the main conductor from the cross wire and the poles.

Number 14, strain insulator, is made of two steel sides and two porcelain insulators two inches in diameter, $\frac{3}{8}$ steel pins holding the sides together. It is used at the terminals of lines to insulate the main conductor from poles, and is strong enough to stand the strain of the main conductor. This insulator and a large turn-buckle (19) are generally placed close together at the anchorage. It is also used whenever a strain on the line is taken up before reaching curves.

Number 15 is an insulator sometimes used in connection with the pole bracket and arm (see 26 and 27) for deflections in the line. It can be used on straight track, but the suspension ring for arm (21) and a cone insulator (9) are preferable.

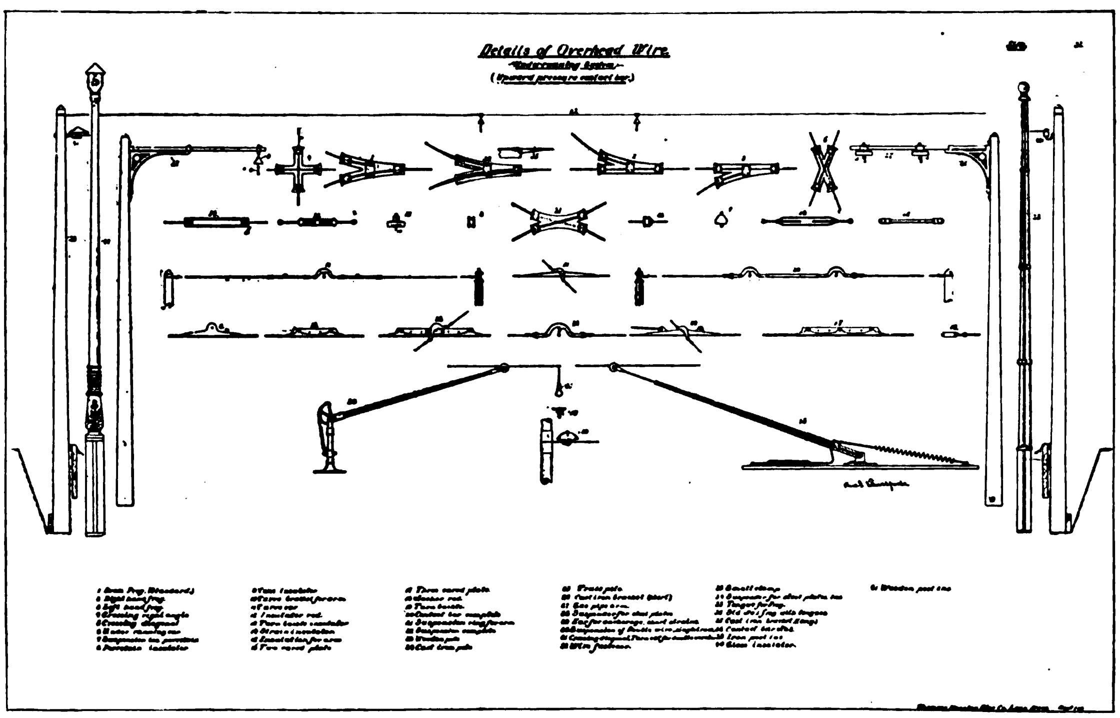

FIG. 6.—Details of Thomson-Houston Overhead Construction.

at present made, it is constructed of paper and wood, is substantial and not easily broken in transportation. This insulator can only be used on straight lines, where the wire has no tendency to pull sideways.

Number 10 is a curve bracket; this bracket is made of cast iron or brass, fastened to the insulator, and is used with the cast-iron bracket and arm (numbers 26 and 27). This method of fastening and insulating overhead conductors can be used on either straight lines or curves and deflections, although on straight lines the common cone insulator is generally used, suspended from an insulated ring, as shown in number 21.

Number 11, curve ear, mentioned above, is made of brass (gun metal). It is given a curved shape—bending above the line—in order to bring the strain of the conductor and the strain of the cross wire in the same plane, so that the curve ear will not be acted upon by a couple tending to deflect it from its proper position. The main conductor is thus held by the curve ear in line with the pull of cross wire, so that there is no tipping over caused by side strain. In order to insulate the curve ear from cross wire and poles, insulator number 12 can be used.

Number 16, two-eared plate, consists of a steel plate about two inches wide provided with two brass ears; the steel plate has drilled holes for suspension from a cone insulator, or it can be bolted to an arm or insulator (15). It is intended for fastening a conductor to an anchorage. In this case the anchor rod (18) is bolted to the steel plate and fastened by means of a wire cable to an anchor pole or other object, capable of standing the strain of the line.

Number 17, three-eared plate, is similar to the two-eared plate, but has three brass ears, and is used for taking up heavy strains and also for joining two conductors end to end.

Number 18 is the anchor rod referred to above, and number 19 is a turn-buckle.

Number 20, contact bar complete, consists of an upright shaft, carried in a cast-iron bottom plate; upon the shaft is slipped a tube to which is jointed, at its upper end, a cam; a stout spiral spring attached to the edge of the cam is secured to the collar near its junction with the bottom plate; to the cam is permanently fastened an arm carrying at its extreme end a contact wheel or trolley, grooved to run on the under side of the suspended main

conductor. The action of the cam will be well understood by reference to the figure; as the arm is depressed when the conductor is low the tension of the spring will be increased but the cam will reduces the leverage at the same time; while on the raising of the arm where the conductor is suspended higher the spring will get weaker when the cam increases the leverage; so that practically an equal pressure is exerted by the contact wheel against the conductor for all heights. The springs on the cam are adjustable. There are several other devices of somewhat different construction for making contact of uniform pressure with the conductors.

Number 21, suspension ring for arm, is a cast iron ring provided with a set screw on its upper part and an eye on its lower part. The lower eye receives the cone insulator.

Number 22 shows a suspension complete, with poles and their breast and heel plates, the cross wire, the porcelain insulator (8), the cone insulator (9), the under-running ear and conductor seen endwise.

Number 23 is a wooden pole. When wooden poles are used they are required to be at least six inches in diameter at top, twenty-one feet out of ground and six feet in the ground for ordinary work.

Number 24 is an ornamental cast iron pole, surmounted by an electric light fixture, so that at night the road can be lighted up either by the main current or by a special circuit as desired. The objection that people have to the placing of poles in front of or near their property is perfectly justifiable, in view of the kind of poles usually selected for telegraph or electric lighting purposes. In an iron pole, however, architectural taste can be displayed; and the poles instead of being an eyesore, become ornamental and in keeping with surroundings. No one objects to an ornamental or even plain gas lamp post, when properly put up; and if electric railways can be run successfully by means of an overhead wire, there can be no reasonable objection to a properly designed structure on the score of appearance.

Number 25, is a truss pole of wrought iron; seldom used. There are many varieties of iron poles. The purpose and cost usually govern their selection.

Number 26, cast iron bracket, is used with a gas pipe arm, number 27, projecting horizontally for the suspension of the overhead conductor.

Number 28 is a suspender for two or three eared plates (numbers 16 and 17).

Number 29, ear for anchorage (short strains), is used where the line has a deflection and anchorage is necessary to take the strain off the conductor.

Number 30 shows the fibre insulation between two conductors when used over a single track.

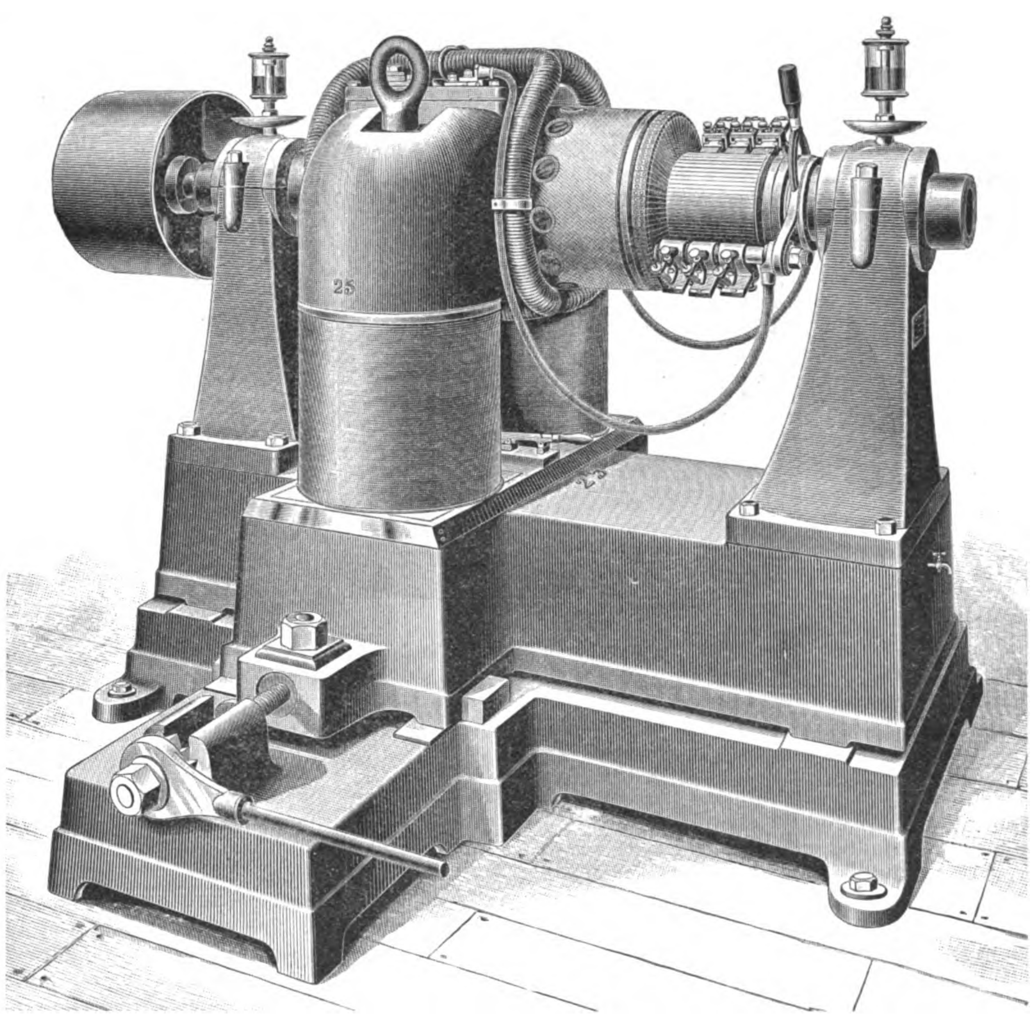

FIG. 7.—Thomson-Houston Dynamo for Railway Service.

Number 31, crossing for two wires, insulating one from the other, is used wherever it is necessary for one wire to cross another, and at the same time be insulated from it.

Number 32, wire fastener. This is used to secure a wire in a neater manner than the ordinary method of twisting it upon itself.

Number 33, small clamp to prevent the slipping of the porcelain insulator along the cross wire on deflections in the line.

Number 34 insulates, by means of a porcelain insulator and two steel straps at each end of number 28, the conductor from the cross wire. This can be used in place of number 12.

Number 35, tongue for frog, prevents the contact wheel from striking the frog box.

Number 36 represents the standard frog complete.

Number 37 represents a cast iron *tong* bracket. Number 38, contact bar number 2, is used where the track passes under a low bridge, the wire being very near the top of the car. This form of contact arm lies nearly flat upon the car when passing under a low portion of the line. Number 39, iron post insulator; number 40, glass insulator, and number 41, wooden pole insulator, are new forms not yet in use.

THE GENERATOR.

The dynamo of the Thomson-Houston railway system is shunt-series wound to give a constant potential. The shunt winding covers the cores of the field magnets in the usual manner. The series winding is peculiar, consisting of separate coils embracing the ends of the pole-pieces and encircling the armature. The circuit connections are on a switch-board, which is bolted fast to the pole-pieces at the top of the machine. (See figure 7.)

This dynamo is of the Thomson-Houston motor type, now familiar to electricians and the public. Its design and construction render all parts easily accessible. The armature bearings are supported in ball boxes, by means of which they automatically allign themselves. The machine most frequently used for railway work is of a potential of 500 volts and is capable of giving 62,500 watts output at a speed of 900 revolutions per minute. The machine is built very substantially. Its weight is 10,000 pounds.

The safety appliances provided with the machine, which are in the nature of automatic cut-offs, are generally arranged to limit the current to about 140 amperes, which is the full load; though oftentimes in railway work, the limit is set a little higher than this because sometimes it is not desirable to have the cut-off operate until a load has been thrown on and maintained which is considerably beyond the ordinary capacity of the machine.

The station equipment, which generally accompanies one or more of these generators, consists of a voltmeter, one or more current indicators, rheostats and lightning arresters for each machine, an equalizing bar to connect the series coils of the machines, and three-point station switches for cutting the current from the line. These are all mounted on a neat board and are generally placed in the dynamo room at a distance of one or two feet from the wall, so that all the connections on the back of the board may be conveniently examined at any time.

MOTORS AND CAR APPARATUS.

In most cases two motors are employed on each car, although for certain conditions one motor is quite sufficient. The motors are generally series wound, and are run in multiple when high speeds are to be obtained. The independence of the driving action of the two motors, when two are used, is obtained by gearing each one to a separate axle. The switches for throwing on and off the current and for suddenly opening the circuit, are special to the Thomson-Houston system, as are also the lightning arresters and fusible plugs. The lightning arresters protect the motors from induced discharges brought about by lightning flashes, or from direct discharges to the main line from the clouds. The fuse wires, of course, have the ordinary function of cutting off the current when it is excessive. They are made to open the circuit at about 50 amperes in ordinary cases. All of these protective devices are provided with means for rupturing any arc which may form between the terminals, either of the switches, lightning arresters or fuse connections. This is rendered desirable, if not necessary, when working with potentials so high as 500 volts, a pressure which is capable of maintaining an arc across a space of considerable length. Thus in opening a switch an arc may still play after the switch has been opened and would damage the switch and its supports. While a number of arc-rupturing devices have been applied to these switches, lightning arresters and fuses, by the Thomson-Houston company, the one which has been adopted as the standard is the magnetic field produced by a current passed through the coils of a powerful electro-magnet, in which field the switch contacts, lightning arrester plates and the fuse connections are mounted. It is understood that the Thomson-Houston company has broad patents on arc-rupturing devices applied in this manner, and which are found so useful in connection with railway work. Great care and attention has evidently been given to the construction of these accessory devices in order to have them of an efficient, practical nature. In addition each car is equipped with a reversing switch and starting rheostat. The rheostat is of special form, put in series with the motors, and enables the starting and stopping of the car to be accomplished without any jerk or sudden strains. The manipulation of the rheostat and reversing switch is accomplished from either end of the car, by what is known as the controlling stand. The field magnets are also operated upon by the controlling stand, so as to change the ampere-turns around the field magnets; and this, together with the rheostat, gives an efficient and thoroughly practical means for operating and controlling the action of the motors. The regulating apparatus is simple in construction and operation and not easily put out of order to give trouble in use. The greatest tractive effort is obtained when the rheostat has been cut out of circuit altogether, thus giving the field magnets their full strength. The increase of effect so obtained reacts upon the armature and causes it to turn with a greater torque and enables the car to do very heavy work; in some cases

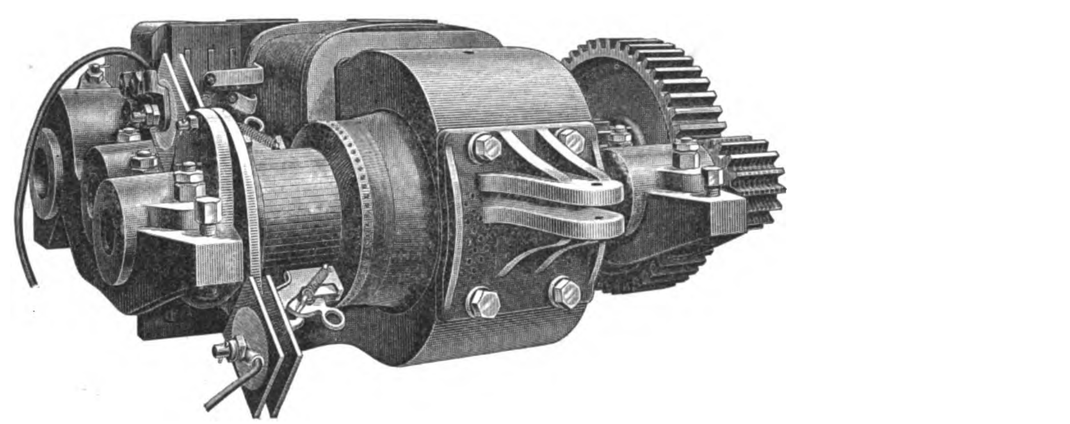

FIG. 8.—Thomson-Houston Railway Motor.

the motor car being used as a towing car for one or more other cars unprovided with electric motor appliances. There are two cut-off switches placed on each car, one at each end, whereby the entire current may be shut off instantly from the motor mechanism in case of accident.

Of the twelve Van Depoele roads in operation when the Thomson-Houston company took over the Van Depoele patents and business, several have been converted to the present Thomson-Houston system. The demand for electric railway outfit has developed so rapidly during the last year that the Thomson-Houston company, notwithstanding its extensive manufacturing capacity, has found it difficult to supply apparatus fast enough, and has found it necessary to increase its facilities by building new factories and shops, and it is utilizing to the utmost such increased facilities.

THE STRENGTH OF THE INDUCED CURRENT WITH A MAGNETO-TELEPHONE TRANSMITTER AS INFLUENCED BY THE STRENGTH OF THE MAGNET.[1]

BY CHARLES R. CROSS AND ARTHUR S. WILLIAMS.

It is a well-known fact in practice, as well as an evident consequence of theoretical considerations, that the effectiveness of a magneto telephone when used either as a transmitter or as a receiver varies with the strength of the magnetism of the core. But the relation of the one to the other has never been studied, so far as we are aware.

Our investigations include a study of the changes in strength of the current produced by a magneto transmitter under varying conditions of magnetization, and of the magnitude of the momentary changes in the magnetic condition of the core of the receiving telephone when subjected to the action of undulatory or other brief currents, as influenced by the strength of the primitive permanent magnetization of the core. The present paper contains only the results of a series of experiments relating to the first of these, that is, to the effect of varying strength in the magnet of the transmitter, the study of the allied problem of the receiver being still in progress.

The apparatus employed consisted of a cylindrical bar of soft iron about 4½ inches in length and one-quarter of an inch in diameter, around one end of which was placed a coil of fine wire similar to that used in ordinary telephonic practice. The resistance of this coil was 100 ohms. It was placed in circuit with a ballistic mirror galvanometer, from whose deflection the momentary current produced in the coil by any variation in the strength of the core could be determined. The diaphragm, which was in all cases 2 5/16 inches in diameter, was in its usual place opposite the end of the magnet about which the wire coil was wound, and about 8/100th of an inch from that end. By means of a rod carrying a cam moved by a weight, a rapid inward push of definite amount was given to the diaphragm, thereby inducing a current in the coil already referred to, and so deflecting the needle of the ballistic galvanometer. The soft iron bar was also surrounded by a second helix, through which was passed a current from a storage battery, serving to magnetize the core. A tangent galvanometer inserted in this circuit gave the strength of the magnetizing current. A magnetometer placed in the prolongation of the axis of the core, which last occupied an east and west position, made known the relative strengths of the field produced by the core under different conditions of magnetization.

Corresponding observations of the magnetometer reading, and of the current induced when the diaphragm was moved by the cam, were made throughout a widely varying range of strength of field, and the results were represented graphically by constructing a series of curves in which ordinates represent the relative strength of field, and abscissas the current due to a given predetermined throw of the diaphragm (about 1/100th of an inch), as ascertained from the readings of the ballistic galvanometer.

One of these curves is shown at 1, figure 1, the core in this case being a cylindrical bar of Norway iron 4½ inches long and one-quarter of an inch in diameter, and the diaphragm an ordinary disc of ferrotype iron 2 5/16 inches in diameter and 1/100 of an inch thick (No. 31 B. W. G.).

Table i. gives the data from which figure 1 was constructed. The strength of field is given in terms of the tangents of the angles of deflection of the magnetometer needle. The induced current is given in arbitrary units, as only relative values are needed. A determination of the value of the deflections was made by observing the excursion due to the discharge of a condenser through the ballistic galvanometer, and it was found that the abscissa 100 on the curves corresponds to a sudden discharge of approximately 0.00000097 of a coulomb through the coils of the galvanometer.

TABLE I.

Core, Norway Iron.—Diaphragm, Disc of Ferrotype Iron, No. 31.

Strength of field.	Induced current.	Strength of field.	Induced current.
....	0.7	.211	20.5
.016	8.8	.229	19.8
.044	12.0	.248	19.2
.058	19.8	.270	18.7
.089	23.8	.302	18.0
.118	27.0	.342	16.9
.141	26.8	.390	16.1
.132	26.6	.454	14.7
.146	25.8	.530	13.8
.164	23.8	.625	12.7
.182	22.5	.778	12.0
.196	21.6	1.014	11.5

Cores of Bessemer steel and of untempered soft steel were also used, with results given in tables ii. and iii.

TABLE II.

Core, Bessemer Steel.—Diaphragm, Disc of Ferrotype Iron, No. 31.

Strength of field.	Induced current.	Strength of field.	Induced current.
.005	2.0	.279	17.8
.030	7.7	.333	16.7
.082	20.7	.396	15.0
.137	26.7	.507	13.5
.160	24.8	.625	11.7
.191	21.2	.748	10.8
.218	19.8	.907	9.7
.248	18.6	1.099	8.7

TABLE III.

Core, Untempered Soft Steel —Diaphragm, Disc of Ferrotype Iron, No. 31.

Strength of field.	Induced current.	Strength of field.	Induced current.
.031	8.2	.275	18.0
.049	12.0	.321	16.5
.089	22.0	.388	15.2
.137	25.9	.478	13.8
.157	24.9	.618	12.7
.171	22.9	.776	11.0
.194	21.1	1.011	9.5
.216	19.7		

An examination of figure 1, as well as of the various curves following it, will show that the effect of increasing the strength of the magnet of the transmitter is in all cases to cause at first a rather rapid increase of the strength of the induced current, which later increases less rapidly, rising soon to a maximum value, from which it falls off, at first rapidly, and afterwards more and more slowly as the strength of the field is further increased. We proceed to consider the explanation of these results.

1. From the Proceedings of the American Academy of Arts and Sciences. Presented November 14, 1888.

It is evident that three distinct sources of variation exist to affect the current furnished by a magneto transmitter as the strength of the magnet is increased. First, the direct effect of the increased strength of field in which the diaphragm moves is to increase proportionally the strength of the induced current, since it increases correspondingly the rate of change in the number of lines of force enclosed by the coil of the instrument; second, an approach toward saturation of the magnet, so far as it alone is concerned, will tend to diminish the induced current, on account of the smaller variation in the strength of the pole due to a given motion of the diaphragm; and, third, the nearer approach toward saturation of the diaphragm will have the same tendency.

The rapid rise in the induced current at the beginning is of course due to the predominating influence of the increasing strength of the field in which the diaphragm moves, as both core and diaphragm are then but slightly magnetized. The subsequent changes in the current must be explained by a consideration of the increasing magnetization of either the core or the diaphragm, or both.

It will be seen by comparing tables i., ii., and iii., that the value of the maximum induced current for a given excursion of the diaphragm is approximately the same with all the three cores used, and that the same is true as to the strength of field corresponding to this maximum current. Moreover, saturation curves constructed for the several cores showed that in all cases the magnet was still very far removed even from half-saturation when the maximum induced current was obtained. From these facts it appears that the degree of saturation of the magnet is practically unimportant, so far as the general results shown in figure 1, are concerned.

It remains to observe the part played by the increasing magnetization of the diaphragm. Other things remaining the same, as this approaches more and more closely towards saturation the increase in the number of lines of force passing between it and the magnet on the approach of the diaphragm to the magnet must become smaller and smaller, and this change will tend to oppose the effect of the increased absolute strength of the magnetizing force. The small mass of diaphragm will evidently cause it to show the effect of an approach to saturation, while the core is far below that condition. And such an action will clearly explain the observed changes in the current strength.

In order to test this matter still further, the experiment was tried of varying the mass and material of the diaphragm.

The results are shown by the curves in figures 1, 2, and 3, which are constructed from the data given in tables i. to x.; further results of the same character are given in tables xi. and xii.

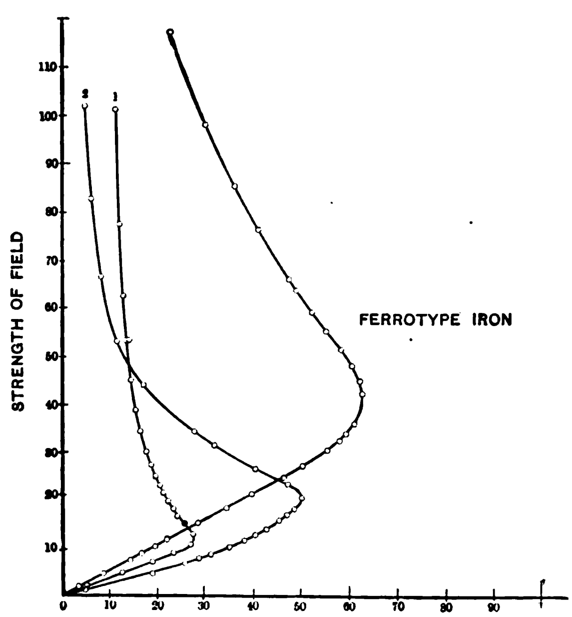

Fig. 1.

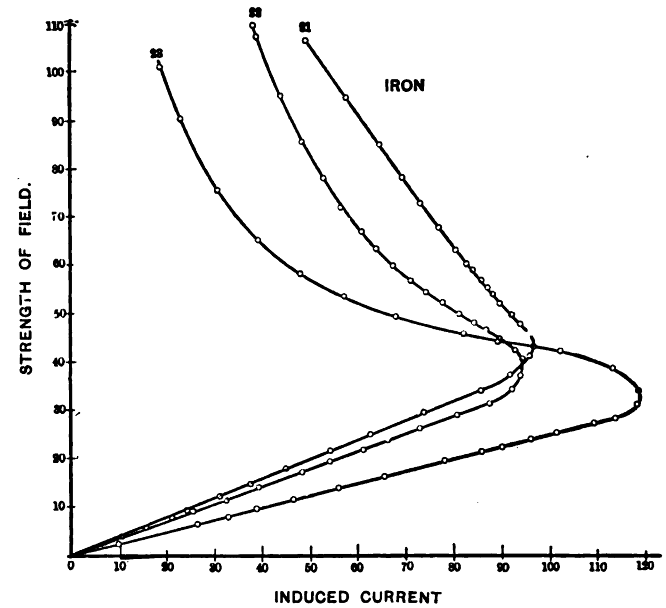

Fig. 2.

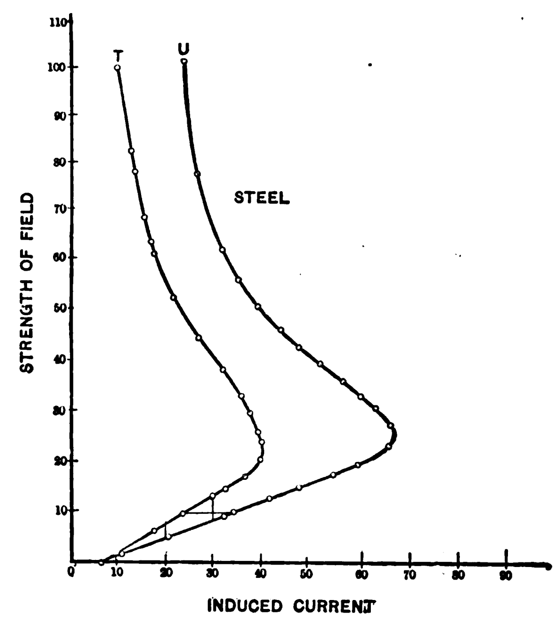

Fig. 3.

TABLE IV.

Core, Norway Iron.—Diaphragm, Two Superposed Discs of Ferrotype Iron, No. 31.

Strength of field.	Induced current.	Strength of field.	Induced current.
.016	5.0	.184	49.8
.054	19.3	.205	50.2
.070	25.7	.229	48.0
.081	28.5	.266	40.8
.089	30.2	.306	31.8
.103	35.0	.342	27.7
.119	38.5	.438	16.7
.133	40.7	.530	11.9
.144	42.7	.667	8.8
.155	45.7	.830	7.0
.169	47.0	1.018	5.0

TABLE V.

Core, Norway Iron.—Diaphragm, Three Superposed Discs of Ferrotype Iron, No. 31.

Strength of field.	Induced current.	Strength of field.	Induced current.
.000	0.5	.346	59.7
.018	3.2	.366	60.7
.047	8.0	.390	61.3
.079	14.2	.416	63.0
.084	14.7	.445	62.3
.096	17.0	.479	61.0
.110	19.7	.514	58.5
.118	21.8	.550	55.7
.135	25.5	.591	52.4
.151	28.3	.637	48.7
.175	33.0	.659	47.3
.213	39.0	.765	41.7
.249	46.3	.854	36.7
.277	49.8	.983	30.0
.313	55.3	1.180	22.8
.329	58.7		

TABLE VI.

Core, Norway Iron.—Diaphragm, Sheet Iron, No. 21.

Strength of field.	Induced current.	Strength of field.	Induced current.
...	0.8	.456	96.7
.016	3.1	.477	94.0
.058	13.7	.499	92.5
.082	20.8	.521	90.5
.102	25.2	.536	88.3
.125	31.2	.578	86.7
.150	37.8	.584	84.0
.178	45.5	.637	81.0
.213	54.7	.675	76.7
.249	63.8	.724	72.3
.296	75.5	.784	69.3
.348	86.2	.851	65.6
.378	92.3	.949	57.3
.416	96.7	1.061	49.1
.437	97.8		

TABLE VII.

Core, Norway Iron.—Diaphragm, Sheet Iron, No. 22.

Strength of field.	Induced current.	Strength of field.	Induced current.
...	1.7	.410	94.2
.018	4.7	.431	92.0
.047	11.7	.452	88.3
.075	19.7	.473	85.0
.088	22.3	.494	81.2
.100	26.0	.516	77.5
.123	32.5	.541	74.7
.146	39.5	.566	71.3
.171	48.2	.601	67.7
.194	54.2	.635	64.0
.218	61.3	.659	60.0
.240	66.9	.719	56.7
.262	73.2	.779	53.0
.292	81.3	.851	48.0
.318	87.7	.946	44.0
.342	92.7	1.072	39.3
.372	94.3	1.091	38.3

TABLE VIII.

Core, Norway Iron.—Diaphragm, Sheet Iron, No. 23.

Strength of field.	Induced current.	Strength of field.	Induced current.
...	1.7	.272	109.8
.026	10.0	.289	113.8
.068	26.8	.310	119.3
.086	33.0	.339	118.6
.096	39.0	.382	114.1
.116	47.0	.420	102.9
.139	56.3	.458	82.2
.162	65.8	.499	68.7
.176	72.3	.529	57.6
.194	78.3	.582	48.0
.216	86.4	.652	39.9
.229	90.0	.751	30.8
.242	96.3	.904	23.7
.255	101.8	1.011	19.0

TABLE IX.

Core, Norway Iron.—Diaphragm, Steel, No. 26, Untempered.

Strength of field.	Induced current.	Strength of field.	Induced current.
.004	7.7	.281	66.7
.019	11.5	.318	63.8
.054	20.5	.342	60.4
.095	32.2	.380	56.3
.105	34.5	.422	50.5
.128	42.0	.483	44.7
.158	48.3	.530	39.0
.178	55.7	.584	35.3
.200	60.3	.652	32.0
.227	64.3	.810	28.2
.236	67.0	1.043	24.3

TABLE X.

Core, Norway Iron.—Diaphragm, Steel, No. 26, Tempered.

Strength of field.	Induced current.	Strength of field	Induced current.
.002	7.8	.344	36.3
.019	10.4	.400	32.0
.068	18.5	.466	26.9
.096	23.8	.545	21.7
.128	30.3	.642	17.7
.151	32.4	.662	17.3
.180	37.0	.732	15.2
.214	40.2	.816	13.8
.246	40.0	.854	13.0
.272	39.5	1.025	10.0
.304	37.9		

TABLE XI.

Core, Norway Iron.—Diaphragm, Steel, No. 22, Untempered.

Strength of field.	Induced current.	Strength of field.	Induced current.
.007	6.2	.272	36.7
.023	8.0	.302	34.8
.070	17.3	.340	33.0
.103	23.0	.392	29.7
.121	26.4	.458	26.3
.139	30.1	.538	23.2
.157	32.8	.566	23.0
.176	35.0	.647	21.7
.202	37.1	.773	19.8
.224	34.9	1.046	17.6
.246	37.0		

TABLE XII.

Core, Norway Iron.—Diaphragm, Steel, No. 30, Tempered.

Strength of field.	Induced current.	Strength of field.	Induced current.
.007	6.2	.272	36.7
.023	8.0	.302	34.8
.070	17.3	.340	33.0
.103	23.0	.392	29.7
.121	26.4	.458	26.3
.139	30.1	.538	23.2
.157	32.8	.566	23.0
.176	35.0	.647	21.7
.202	37.1	.773	19.8
.224	...	1.046	17.6
.246	37.0		

TABLE XIII.

Core, Norway Iron.—Diaphragm, Steel, No. 30, Untempered.

Strength of field.	Induced current.	Strength of field.	Induced current.
.005	5.2	.331	31.2
.031	11.7	.376	28.9
.082	24.2	.437	26.0
.103	29.7	.512	23.3
.130	37.7	.632	20.4
.160	41.9	.735	19.7
.200	38.3	.819	18.0
.231	36.2	.956	16.3
.272	35.2		

Curve 2, figure 1, represents the results when two of the ordinary ferrotype diaphragms were superposed, forming a diaphragm of double thickness, and curve 3 of the same figure shows the results when three such diaphragms were superposed. Each diaphragm was 0.01 of an inch thick. The curves of figure 2, marked 21, 22, 23, respectively, show the results of similar experiments with diaphragms of sheet iron whose thickness was 0.030, 0.027, 0.024 of an inch, respectively (Nos. 21, 22, 23, B. W. G.). Figure 3 shows the results when a steel diaphragm 0.017 of an inch thick (No. 26) was used, the curve U being that for untempered steel, and T that for tempered steel. Steel diaphragms respectively 0.026 and 0.012 of an inch thick (Nos. 22 and 30) gave similar results, as will be seen from tables xi., xii., and xiii.

An inspection of these curves shows immediately that the greater the strength of the field required to saturate the diaphragm, the greater is the strength of the field at which the maximum current occurs. Thus in figure 1 the maximum current with curve 1 corresponds to a strength of field of about 12 units of the scale used, while with curves 2 and 3 the corresponding strengths of field are 20 and 43 units respectively. Also in figure 2 the maximum currents will be seen to correspond to greater strengths of field in proportion to the thickness of the diaphragm, and in figure 3 similar though less marked results hold for tempered as compared with untempered steel of the same thickness.

It would also be expected that the value of the maximum current would be greater with a thick than with a thin diaphragm. This was usually the case in our experiments. Thus the curves 1, 2, 3, of figure 1 give maximum currents of 27.5, 50.2, and 62.6 units respectively. Results of a similar nature are shown by figure 3, the maximum current with the untempered diaphragm being far greater than with the tempered one. Curve No. 23 of figure 2 is apparently an exception. It is probable, however, that this is in appearance only, and that the three curves of that figure are not strictly comparable with one another. The rigidity of the diaphragms here used, especially of the thicker ones, is considerable, and any slight yielding of the supports of the rod which carried the cam would prevent the actual throw of the diaphragm from being as great when this had considerable thickness, and would greatly diminish the strength of the current produced.

The peculiarity of curve 2, as compared with 1 and 3, is probably caused by the want of both magnetic and mechanical continuity in the material of the multiple plate formed by the several diaphragms used.

In those cases where steel diaphragms were employed, there was always a notable induced current, even when the reading of the magnetometer was zero. This was probably due to a slight residual magnetization of the diaphragms.

The results stated in this paper may serve to explain a phenomenon which has seemed somewhat obscure. Frequent attempts have been made to increase the efficiency of a magneto transmitter by polarizing the diaphragm as well as the magnet, a common way of doing this being to employ a horseshoe magnet one leg of which is in contact with the edge of the diaphragm, while the other, about which the coil is wound, is placed in its usual position opposite the centre. But as a general rule little or no gain has seemed to result therefrom, so far as can be judged by the performance of such instruments in actual practice. It is quite probable in this case that the increased approach to saturation of the diaphragm may have so great an effect as entirely to prevent the expected improvement.

It will also be seen from our results, that an increase in the thickness of the diaphragm of a magneto transmitter tends to allow of the use of a stronger magnet, and for a given amplitude of vibration to produce a stronger current. But it must be remembered, on the other hand, that the greater rigidity of the thick diaphragm will diminish this range of vibration under the action of the voice, a difficulty which may to a certain extent be remedied by using a diaphragm of large diameter.

Rogers' Laboratory of Physics,
October, 1888.

ARC LAMPS AND THEIR MECHANISM.[1]

BY PROFESSOR SILVANUS THOMPSON, D. SC., M. I. E. E.

An arc lamp being an apparatus for transforming the electric energy supplied to it through the conducting wires into heat and light, it obviously cannot be expected to give a steady illumination unless it can be so arranged and operated that, in the first place, the rate at which it appropriates and transforms the electric energy is constant, and that, in the second place, the circumstances attending this transformation (in respect of the triple relation between the quantity of heat evolved, the degree of temperature, and the emissivity of the incandescent surface), also remain constant. The first of these two provisos relates to the operation of the system of lamps and dynamos (or other means of electric supply) acting conjointly; the second of them relates solely to the quality of the carbon pencils used as electrodes.

As the latter is a simple matter, it may be disposed of first. Suppose the pencils to be composed of a homogeneous carbon, the physical properties of which, such as hardness, specific thermal capacity, conductivity for electricity, conductivity for heat, emissivity, etc., are constant; also that they are cylindrical and of given diameter. Then it follows that if energy is being expended at a uniform rate in heating the tips of a pencil it will be maintained at a uniform temperature, and the amount of light emitted per square millimeter of the surface will be constant, and, as the section is constant, the rate of consumption constant, and the pencil homogeneous, the form once acquired by the incandescent tip (whether positive crater or negative peak) will remain constant. It may be remarked, in passing, that the researches of Captain Abney have shown that the white light of the incandescent carbon surface of the crater at the positive pole of the arc is always of precisely the same composition in respect to the relative proportions of waves of different colors. This most important observation indicates beyond doubt that the temperature of the actual light-emitting surface is always the same. Indeed, this ought to be the case if the latent heat of vaporization of carbon be a positive quantity. When the surface attains this temperature, volatilization begins; and when so begun the temperature cannot rise further, any more than ice can be raised above its temperature of fusion. The limiting temperature of the voltaic arc is the temperature of volatilization of the material of the electrodes. This is, in itself, a reason why the introduction of all known foreign substances whatsoever into the carbon pencils of the arc is found to lower its intrinsic brilliancy; for all known elements have a lower temperature of volatilization, and all compounds are dissociated at arc temperatures.

If, then, we may assume homogeneity of the carbons to be used, the steadiness of the arc light will depend solely upon the maintenance of a steady rate of appropriating and transforming electric energy. How a want of homogeneity may be compensated for in the actual working of the lamp is a point reserved for consideration later.

The rate at which electric energy is appropriated from the wires, and transformed in the lamp into heat and light, always depends both upon the construction of the lamp and upon the conditions imposed upon the system of electric supply. This is a mere consequence of the fact, well known to every electric engineer, that the amount of electric energy per second appropriated by any electric device, motor, or accumulator, is itself the product of two quantities—the current and the pressure (or potential) at which

1. Paper read before The Society of Arts, London, March 6, 1889.

the current is supplied. To put the matter in electricians' language, the number of *watts* of electric energy per second appropriated by the lamp[2] is equal to the number of *amperes* that flow through it multiplied by the number of *volts* that may be applied as a difference of potentials between its two terminals. To keep constant the *product* of the amperes and the volts is the practical problem which the mechanism of the arc lamp must be designed to solve.

A point of much theoretical interest, and in reality of great practical importance, is the fact, long disputed, now established beyond question, that the arc itself does not act simply as an added resistance in the path of the current, but exercises also a counter electromotive force, and tends to set up an opposing current. The apparent resistance of the arc resembles that of an electrolytic cell, or that of an electric motor when running, or, that of a thermopile when a current from an external source is passed through it. The current which flows through the arc arouses, by a species of polarization, an opposing electromotive force. The simplest fact in proof of this is that, unlike any ordinary conductor, the apparent resistance of the arc is not proportional to its length. The apparent resistance of an arc two millimeters in length between the carbon tips is not double that of an arc one millimeter in length, nor anything near double. The fairest way to investigate the matter is to make a series of experiments with arcs of different lengths, the current being independently so regulated as to be maintained of the same strength in each case. There appears to be a true resistance proportional to the length, and a back electromotive force which in steady arcs, and with currents of from seven to fifteen amperes, appears to be about thirty-eight to thirty-nine volts. When the arc hisses, as often happens if the length of it be very short, the back electromotive force fluctuates very much, but always drops to something under twenty volts. Except in the case of constant current circuits, this causes a sudden increase of current when the lamp begins to hiss, and it may be noticed that the light, though unsteady during hissing, is brighter at the negative pole of the arc.

Hitherto, all guesses as to the cause of this counter-electromotive force have been very vague, not to say wild. To account for thirty-nine volts of polarization on any hypothesis that it is due to electrolytic or thermo-electric action, is to suggest causes which are, to say the least, wholly inadequate. The explanation which for the past two years I have been in the habit of suggesting to my students, and which has not been otherwise published hitherto, is as follows:—Every reversible phenomenon which the current can itself produce, and which requires an expenditure of energy for its production, necessarily implies the exhibition of a counter electromotive force. One has only to look at the cases of the reversible chemical action in a cell, of the reversible magneto-mechanical action of a motor, the reversible heating effects of a thermo-electric junction, to comprehend this. Now the phenomenon of volatilization is a reversible one: give to the solid carbon at its volatilization-temperature the necessary latent heat, it is changed to vapor; take from the vapor its latent heat, it condenses back to solid carbon. The arc under normal circumstances is the seat of an actual evaporation of carbon at the positive pole, as well as of a combustion at both poles. So far as any data exist, it appears that the excess of carbon consumed at the positive pole by an ordinary continuous current, is about 0.5 grammes per ampere-hour. if we knew the latent heat of volatilization of carbon per gramme we could calculate *a priori* the necessary minimum electromotive force at the positive pole, which would obviously represent the counter electromotive force so far as it is situated at that point. With long arcs the excess of consumption of the positive pencil over that of the negative is both less and more regular than that which occurs with short arcs. With short arcs three other phenomena occur, which are important in this connection. Firstly, the short arc is liable to whistle or hiss, giving evidence of instability; secondly, it frequently gives rise to "mushrooms," or irregular growths of carbon upon the apex of the negative pencil; thirdly, when it hisses the counter-electromotive force becomes very unsteady, but appears to have an average value about half that of the steady long arc. It is worth while to throw out the suggestion, that the condensation of carbon at the negative pole, in the short arc, is accountable for the change in electromotive force, and for the instability which manifests itself by the hissing sound.

Passing from these conjectures to the construction of lamps for the production of light by the arc, we are now prepared to lay down the points which must be provided for in every arc lamp. It must be emphatically pointed out at the outset that, as a performance of a lamp depends upon the conditions under which it is supplied with electric energy by the circuit, the design of the lamp necessarily also depends on those conditions. In the present state of the art of electric distribution we may classify the conditions of electric supply under the following heads:—

I.—CONTINUOUS SUPPLY AT CONSTANT POTENTIAL.

In this case the arc lamps are arranged either simply all in parallel or in parallels containing two in series; the currents being divided by mains and branches to the lamps. At least 55 volts should be allowed between the mains for single arcs. Practice shows that arc lamps in parallel burn more steadily if a resistance wire of .25 to 1.0 ohm be included in the lamp circuit. Taking the back electromotive force of a steady arc at 39 volts, it is obvious that the excess of the volts at the mains over this represents the volts used in driving the current through the actual resistance in the main circuit of the lamp. This resistance consists of four parts—the true resistance of the arc itself, which may vary from $\frac{1}{10}$ to $\frac{1}{2}$ ohm; the resistance of the carbon pencils, which averages about 0.15 ohm per foot per plain carbons; the resistance of the main circuit coils, which varies in different lamps from 0.05 to 0.2 ohm; and the resistance of the wire introduced for steadying the lamp. In a 10-ampere lamp, working at 55 volts at the mains, 16 volts remain after deducting 39 for the back electromotive force, and these 16 are approximately distributed as follows:—2 volts in the arc itself, 3 volts in the carbons (say 2 feet long in the total), 1 volt in the main coil, and 10 volts in the steadying resistance.

2. Strictly speaking, the actual number of *watts* utilized in the arc is somewhat less than the whole number received from the supply, as a portion of the energy is expended in passing the current through the regulating coils, and another portion is lost in consequence of the resistance offered by the pencils of carbon themselves, and is merely expended in warming them. We may calculate the former loss as follows:—Let E represent the whole number of volts from terminal to terminal, and let i represent the whole current supplied, then the whole number of watts supplied is Ei. Let the *ohms* of resistance of the regulating coils in the main circuit be called a, and that of the shunt coils be called b, that of the carbon pencils themselves c, and that of the resistance coils sometimes used in the main circuit to steady the arc, r. Also, in the case where the lamp has a shunt circuit, let the portion of i which passes through the carbons be called i_1, and that which goes through the shunt, i^2; so that $i_1 + i_2 = i$. The losses are then as follows:—

$$ai_1^2 = \text{watts lost in main circuit coil;}$$
$$bi^2 = E^2 + b = \text{watts lost in shunt coil;}$$
$$ci_2^1 = \text{watts lost in warming carbon pencil;}$$
$$ri^2 = \text{watts lost in the resistance coil.}$$

The resistance of carbon pencils is usually small, and may be materially reduced by a thin coating of copper. The carbons used in commerce (11 to 15 millimeters in diameter) vary from about 0.15 to 0.2 ohms per foot, if plain, and from 0.001 to 0.09 if coppered. Cored carbons have a higher resistance than uncored. Carbons cut from solid gas coke have from five to twenty times as much resistance as those made by the usual modern processes. When lamps are run in series, the resistance offered by the pencils is of more importance; for example, a set of 50 lamps newly trimmed with long carbons may offer 25 ohms more resistance than when all the carbons have burned down short. The resistance, a, of the regulating coils that are in the main circuit differs in different lamps, but may be taken at from 0.05 to 0.2 ohms. The resistance, b, of the shunt coils, is seldom less than 200 ohms, and may be as much as from 400 to 500 ohms. Of the volts, E, applied to the lamp, only a part is utilized, the lost volts being accounted for by the resistances in the path of the current. If these are deducted from the applied electromotive force, there will remain a certain number of volts, which we may call e, which are available as a useful difference of potential at the arc itself. To measure e directly, one has only to apply a voltmeter, making the contacts of its two leading wires to the two carbons at points respectively just above and just below the incandescent tips. The watts actually utilized in the arc are then calculated as the product ei_1. As shown above, e is less than E, and, indeed, may be considerably less, the lost volts depending upon the resistances introduced, and on the current flowing through them. If E is constant, e will not necessarily be so, but will be very nearly if i is also constant. Also i_1 is less than i in all lamps that have a shunt regulating coil, but is not usually more than from 3 to 5 per cent less than i, so that in the cases where i is kept constant, i_1 will be nearly so also.

II.—CONTINUOUS SUPPLY WITH CONSTANT CURRENT.

In this case the arc lamps are arranged in series, the whole of the current going from one lamp to the next, and returning to the dynamo after having traversed successively all the lamps. This is, *par excellence*, the arc light system of distribution, the parallel system at constant potential requiring heavier mains. As the lamps arranged in series tend to steady one another, it is not necessary to allow more than 45 to 50 volts per lamp, including the ordinary lengths of cable from lamp to lamp. From 5 to 10 amperes is the usual current for arc lamps in series.

III.—ALTERNATING SUPPLY AT CONSTANT POTENTIAL.

In this case, also, the lamps are usually arranged as in the first case, the only difference being in certain structural details, such as lamination of iron cores.

IV.—ALTERNATING SUPPLY WITH CONSTANT CURRENT.

This case can hardly be said to be practical, though alternate current dynamos, capable of supplying 6 or 8 lamps in series, have been constructed in past years.

The supply systems, whether continuous or alternating, must be assumed, for the purpose of this paper, to perform efficiently what they profess, namely, to maintain constant one of the two factors of the electric power which they supply to the distributing system. In each case it remains for the mechanism of the lamp to effect such adjustment as will maintain constant the other factor of the product. If the condition of supply is "at constant potential," then it is for the lamp itself so to adjust its carbons as to keep the current through the arc constant. If the condition of supply is "with constant current," then the lamp must adjust its carbons to maintain between them the requisite potential. Hence the differences which are necessary in construction between those lamps which are to work "at constant potential" (in parallel) and those which are to work with constant current (in series). These differences, as will now be shown, chiefly affect the "feeding" mechanisms of the lamp.

In discussing the necessary mechanisms of arc lamps, no further reference will be made to lamps of the Jablochkoff candle type, nor to those with abutment blocks of marble ("Sun" lamp, etc.), nor to the so-called incandescence arc ("Semi-incandescent") lamps, nor to those with curved carbons (Heinrichs's type), nor yet to those horizontal carbons (De Mersanne's, Solignac's, etc.).

NECESSARY MECHANISM OF ARC LAMPS.

[A.] *Driving power.*—In every lamp some means or mechanism is required to propel the carbons toward one another as they burn away, gravity being by far the most common agency for doing this.

[B.] *Striking mechanism.*—In every arc lamp it is requisite to provide a mechanism for bringing the tips of the carbon pencils into contact, and then parting them asunder to the requisite distance across which the arc or flame plays. If, as in most lamps, the carbons are in contact when the lamp is out of action, then a mechanism is required simply to part them as soon as the current is turned on. The operation of producing the arc by parting the carbons is known as "striking" the arc. The mechanism must be automatic, so as to come into action not only when the current is first turned on, but at any subsequent time if from any cause the arc fails. An adjustment, *b*, of the striking mechanism is also usually added to permit of regulation in the length of the stroke or initial distance between the poles.

[C.] *Feeding mechanism.*—As the carbons burn away, one or both of them must be propelled forward to maintain the arc at its proper size. This action is called "feeding" the arc. This action ought to take place by small and imperceptible amounts, and as the rate of consumption of the carbons is continually varying, even with carbons of the best modern manufacture, the lamp must itself regulate the rate at which the pencils are propelled forward in automatic correspondence with the consumption for the time being. Further, since the presence of soft and more readily volatilized portions in the pencils seems to be unavoidable, provision ought to be made so that, whenever the pencil burns down to such a portion, causing a sudden increase in the volume of the flame or arc—technically called a "blower"—the mechanism of the lamp ought at once automatically to draw apart the pencils to a slightly greater distance. A lamp which has a *retractile* motion in either its feeding or its striking mechanism is superior to one that has not, as it can be used with cheaper and less pure brands of carbons. An adjustment, *c*, for regulating the frequency or range of the feeding movements is usual.

[D.] *Replacement mechanism.*—When the pair of carbon pencils has burned away, the lamp trimmer has to replace the stumps by a new pair of long carbons. In order to admit these, the carbon holders must be pushed apart to their widest extent. Special mechanical devices for allowing this motion to occur have to be provided in some forms of lamp, whilst other forms need no special device.

[E.] *Moderating mechanism.*—To prevent the carbon from making too sudden motions, it is usual to add a moderating device, such as a dash-pot, or, in the case of those lamps in which there is a train of wheels, a fan or a governor.

So far, the devices enumerated have been such as are common to all classes of lamps. Those which follow are only required in particular types of lamp.

[F.] *Focusing mechanism.*—In all those cases where it is desired that the luminous points should occupy a fixed position in space, some additional mechanism is necessary to make the arc lamp keep its focus. In lamps designed for the mere lighting of area, this is not important, and in the vast majority of these the upper carbon descends whilst the lower carbon (the negative) is fixed; the luminous point slowly shifting downwards as the carbons consume. All devices for causing the carbons to move forward at such relative rates as to keep an approximately fixed position for the arc will be discussed, together with their methods of adjustment, *f*, under the heading of focusing mechanism.

[G.] *Change-over mechanism.*—Lamps that must run for many hours continuously must be supplied with two pairs of pencils, because it is neither practicable nor advisable to use pencils of extreme length. In the double lamps it is appropriate to provide such arrangements as shall cause one pair of pencils to come into operation first, and when these are consumed away, shall change over the action, either by electrical or by mechanical devices, so that the second pair of pencils shall come into operation.

[H.] *Cut-out mechanism.*—Lamps intended for series working must be provided with some contrivance to prevent the extinction of the whole series when from any cause there is a failure of the light in any one lamp. The usual device is a sort of automatic relay arranged in connection with each lamp, to come into operation in the event of its failure, the operation of the device being (1) to cut the faulty lamp out of circuit by simply short-circuiting it, or (2) to substitute for it a wire of suitable resistance, or (3) to replace it by an auxiliary lamp. The device for performing either of the two former operations is technically known as a "cut-out."

SUPPLEMENTARY CONTRIVANCES.

In addition to the eight distinct species of contrivances above enumerated, there are numerous details which might be further classified; such, for example, as devices for *clamping* the carbon pencils to their respective holders in true allignment; devices for raising and lowering the lamps. For these, however, there is no space. Neither is it possible to enumerate the devices which have been sug-

gested [Staite, Siemens, Brockie, Andrews, Crompton, Swinburne, and others] for *compensating*, in lamps whose action depends on the weight of the descending carbon pencil and its holder, for the diminution of pull as the pencil is consumed.

SCHEDULE OF MECHANISMS.

A schedule embracing the eight heads above enumerated, if supplemented by statements of the gauges and resistance of the wires used in the winding of the coils, affords a systematic and very convenient method of tabulating the facts concerning the construction of any arc lamp. An example of such schedule, filled up with the data of one arc lamp of recent pattern, is given at the end of this paper.

ELECTRO-MAGNETS FOR ARC LAMPS.

As the electro-magnet plays so essential a part in the striking, feeding, and cut-out mechanisms of lamps, a short digression upon the particular forms of electro-magnets appropriate to arc lamps is not out of place. The ordinary treatises on electricity have little to tell about the special properties of different forms of electro-magnet; indeed, this all-important organ in modern electrical engineering has received very inadequate attention from writers on electricity. It is a familiar fact that the attraction of a horseshoe-shaped magnet, whether of steel or iron, varies very greatly with the position of the iron armature, being great at small distances, but very rapidly falling away as the intervening space is increased. To devise a form of electro-magnet whose attractive power shall be exerted over a fairly long range was at one time one of the practical problems of electricians, and it has been solved in various ways. The attraction which a solenoid, or tubular coil, exerts, when traversed by a current, upon an iron core introduced within its aperture, is not, in any position of the core, nearly as great as that exercised by an electro-magnet of horseshoe type, constructed of equal amounts of metal, and energized by an equal current. On the other hand, the feebler pull of the solenoid upon its core is exerted through a very extended range. And by making the core of conical form, or by winding the coils of the solenoid in a conical fashion, it is possible still more completely to equalize the pull over a long range. Solenoids with cores are used in several well-known types of lamps in which a long travel is required. On the other hand, since the operation of striking the arc requires a short motion not exceeding one-twelfth of an inch, or two millimeters, in all those types of lamp in which a special electro-magnet is used simply to strike the arc, a form of electro-magnet is required which will exert a powerful pull over a short range. Further, for working certain clutch mechanisms and the like, it is desirable that a form of electro-magnet should be found which, whilst having a travel of, say one inch, should exert throughout the whole of that range a fairly strong pull, increasing of course toward the end. Experiments show that the special forms of electro-magnets may be tabulated as follows :—

(*a*) *Short-range magnets.*—1. Horseshoe form, if constructed with short thick cores, thick yoke and thick armature, giving compact magnetic circuit.

2. "Pot-magnet," straight core with external tubular envelope, connected by iron at bottom. Armature, a stout iron disc or lid.

(*b*) *Moderate-range magnets.*—1. Horseshoe form with long thin cores and armature, giving a non-compact circuit.

2. Solenoid having a short fixed core extending part of the way down, and a second movable core to be attracted in as plunger. The name "stopped solenoid" is suggested as appropriate for this form.

3. Two such as last, having a yoke connecting the two fixed cores, and a second yoke connecting movable cores.

4. Stopped solenoid with plunger attached to an outer mantle [Kennedy's lamp, figure 10].

5. Electro-magnet with conical poles protruding through hollow in armature [Thomson-Houston lamps, figures 14 and 25].

6. Electro-magnets with oblique approach of armature. [Serrin's, figure 5; De Puydt's, figure 23; and many other lamps.]

(*c*) *Long-range magnets* —1. Solenoid, cylindrical, with longer cylindrical core. Attraction greatest when entrant end of core just reaches the further side.

2. Solenoid, cylindrical, with long coned core entering with the point foremost.

3. Solenoid, conical, with long cylindrical core entering the thicker end of solenoid.

4. Special device for travel of unlimited length. A solenoid constructed in sections, which are switched into circuit progressively ahead of the core as the core travels down[3] [Thomas, 578[82]; Lindemann, 16,376[87]].

It must be borne in mind that the range of an electro-magnet depends on the relative dispositions of the iron parts of the magnetic circuit and of the magnetizing copper parts, and in no way upon the question whether the coil consists of a few turns of thick wire, or of many turns of thin wire.

(*To be continued.*)

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.[1]

BY G. W. DE TUNZELMANN, B. SC.

(Continued from page 172.)

Dr. Hertz was at first inclined to suppose that as the micrometer circuit was only broken by the extremely short air space limited by the maximum sparking distance under the conditions of the experiment, it might therefore be treated as a closed circuit, and only the total induction considered. The ordinary methods of electro-dynamics give the means of completely determining the total inductive effect of a current element on a closed circuit, and would, therefore, in this case have sufficed for the investigation of the phenomena observed. He found, however, that the treatment of the micrometer circuit as a closed circuit led to incorrect results, so that it, as well as the primary, had to be treated as an open circuit, and, therefore, a knowledge of the total induction was insufficient, and it became necessary to consider the value both of the E. M. F. induction and of the electrostatic E. M. F. due to the charged extremities of the exciting circuit at each point of the micrometer circuit.

The investigations to which these considerations led are described by Dr. Hertz in a paper "On the Action of a Rectilinear Electrical Oscillation upon a Circuit in its Vicinity," published in Wiedemann's *Annalen*, vol. xxxiv., p. 155, 1888.

In what follows, the exciting circuit will be spoken of as the primary, and the micrometer circuit as the secondary. Hertz points out that the reason that the electrostatic effect cannot be neglected is to be found in the extreme rapidity with which the electrostatic forces change their sign. If the electrostatic alternations in the primary were comparatively slow they might attain a very high intensity without giving rise to a spark in the secondary, since the electrostatic distribution on the secondary would vary so as to remain in equilibrium with the external E. M. F. This, however, is impossible, because the variations in direction follow each other too rapidly for the distribution to follow them.

In the present investigations the primary circuit consisted of a straight copper wire five millimeters in diameter, carrying at its extremities hollow zinc spheres 30

3. Figures in square brackets relate to patent specification or date.

1. From the *Electrician* (London).

centimeters in diameter. The centres of the spheres were one meter apart, and at the middle of the wire was an air space $\frac{3}{4}$ centimeter in length. The wire was placed in a horizontal position, and the observations were all made at points near to the horizontal plane through it, which, however, did not, of course, affect their generality, as the same effects would necessarily be produced in any plane through the horizontal wire. The secondary circuit consisted of a circle of 35 centimeters radius of copper wire two millimeters in diameter, the circle being broken by an air space capable of variation by means of a micrometer screw.

The circular form was selected for the secondary circuit because the former investigations had shown that the sparking distance was not the same at all points of the secondary, even when the conductor as a whole remained unchanged in position, and with a circular circuit it was easier to bring the air space to any part than if any other form had been used. To attain this object the circle was made movable about an axis passing through its centre perpendicular to its plane.

The circuits of the dimensions stated were very nearly in unison, and they were further adjusted by means of little strips of metal soldered to the extremities, and varied in length until the maximum sparking distance was obtained.

We shall follow Dr. Hertz in first considering the subject theoretically, and then examining how far the experimental results are in accordance with the theoretical conclusions. It will be assumed that the E. M. F. at every point is a simple harmonic function of the time, but that it does not undergo reversal in direction, and it will further be assumed that the oscillations are at any given moment everywhere in the same phase. This will certainly be the case in the immediate neigborhood of the primary, and for the present we shall confine our attention to such points. Let s be the distance of a point, measured along the circuit from the air space of the secondary, and F the component E. M. F. at that point along the circular arc $d\,s$. Then F is a function of s, which assumes its original value after passing once round the circle of circumference S. It may, therefore, be expanded in the form

$$F = A + B \cos\frac{2\,\pi\,s}{S} \ldots\ldots + B' \sin\frac{2\,\pi\,s}{S} + \ldots\ldots$$

The higher terms of the series may be neglected, as the only result of so doing will be that the approximate theory will give an absolute disappearance of sparks where really the disappearance is not quite complete, and indeed the experiments are not delicate enough to enable us to compare their results with theory beyond a first approximation.

The force A acts in the same direction, and is of constant amount at all points of the circle, and therefore it must be independent of the electrostatic E. M. F., as the integral of the latter round the circle is zero. A then, represents the total E. M. F. of induction, which is measured by the rate of variation of the number of magnetic lines of force which pass through the circle. If the electromagnetic field containing the circle is assumed to be uniform, A will therefore be proportional to the component of the magnetic induction perpendicular to the plane of the secondary. It will therefore vanish when the direction of the magnetic induction lies in the plane of the secondary. A will consist of an oscillation, the intensity of which is independent of the position of the air space in the circle, and the corresponding sparking distance will be called a.

The term $B' \sin\frac{2\,\pi\,s}{S}$ can have no effect in exciting the fundamental vibration of the secondary, since it is symmetrical on opposite sides of the air space.

The term $B \cos\frac{2\,\pi\,s}{S}$ will give a force acting in the same direction in the two quadrants opposed to the air space, and will excite the fundamental vibration. In the two quadrants adjacent to the air space it will give a force in the opposite direction, but its effect will be less than that of the former one. For the current is zero at the extremities of the circuit, and therefore the electricity cannot move so freely as near the centre. This corresponds to the fact that if a string fastened at each end has its central portion and ends acted on respectively by oppositely directed forces, its motion will be that due to the force at the central portion, which will excite the fundamental vibration if its oscillations are in unison with the latter. The intensity of the vibration will be proportional to B. Let E be the total E. M. F. in the uniform field of the secondary, φ the angle between its direction and the plane of the latter, θ the angle which its projection on this plane makes with the radius drawn to the air space. Then we shall have approximately

$$F = E \cos \varphi \sin\left(\frac{2\,\pi\,s}{S} - \theta\right),$$

and, therefore, $B = -E \cos \varphi \sin \theta$.

B, therefore, is a function simply of the total E. M. F. due both to the electrostatic and electro-dynamic actions. It will vanish when $\varphi = 90°$—that is to say, when the total E. M. F. is perpendicular to the plane of the circle, whatever be the position of the air space on the circle. B will also vanish when $\theta = 0$—that is to say, when the projection of the E. M. F. on the plane of the circle coincides with the radius through the air space. If the position of the air space on the circle is varied, the angle θ will vary, and, therefore, also the intensity of the vibration and the sparking distance. The sparking distance corresponding to the second term of the expansion for F can, therefore, be represented approximately by a formula of the form $\beta \sin \theta$.

Now the oscillations giving rise to sparks of lengths a and $\beta \sin \theta$ respectively are in the same phase. The resulting oscillations will therefore be in the same phase, and their amplitudes must be added together. The sparking distance being approximately proportional to the maximum total amplitude may therefore also be obtained by adding the sparking distances due to the two oscillations respectively. The sparking distance will therefore be given as a function of the position of the air space on the secondary circuit by the expression $a + \beta \sin \theta$. Since the direction of the oscillation in the air space does not come into consideration we are concerned only with the absolute value of this expression, and not with its sign. The determination of the absolute values of the quantities a and β would involve elaborate theoretical investigations, and is, moreover, unnecessary for the explanation of the experimental results.

Experiments with the secondary circuit in a vertical plane.—When the circle forming the secondary circuit was placed with its plane vertical, anywhere in the neighborhood of the primary, the following results were obtained:—

The sparks disappeared for two positions of the air space, separated by 1·0°, namely, those in which it lay in the horizontal plane through the primary; but in every other position sparks of greater or less length were observed.

From this it followed that the value of a must have been constantly zero, and that θ was zero when the air space was in the horizontal plane through the primary.

The electro-magnetic lines of force must therefore have been perpendicular to this horizontal plane, and therefore consisted of circles with their centres on the primary, while the electrostatic lines of force must have been entirely in the horizontal plane, and therefore this system of lines of force consisted of curves lying in planes passing through the primary. Both of these results are in agreement with theory.

When the air space was at its greatest distance from the plane the sparking distance attained a maximum value of

from two to three millimeters. The sparks were shown to be due to the fundamental vibration, by slightly varying the secondary, so as to throw it out of unison with the primary, when the sparking distance was diminished, which would not have been the case if the sparks had been due to overtones. Moreover, the sparks disappeared when the secondary was cut at its points of intersection with the horizontal plane through the primary, though these would be nodal points for the first overtone.

When the air space was kept at its greatest possible distance from the horizontal plane through the primary, and turned about a vertical axis, the sparking distance attained two maxima at the points for which $\varphi = 0$, and almost disappeared at the points for which $\varphi = 90°$.

The lower half of figure 8 shows the different positions of minimum sparking. A A′ is the primary conductor, and the lines $m\ n$ represent the projections of the secondary circuit on the horizontal plane. The arrows perpendicular to these give the direction of the resultant lines of force. As this did not anywhere vanish in passing from the sphere A to the sphere A′, it could not change its sign.

The diagram brings out the two following points:—

(1) The distribution of the resultant E. M. F. in the vicinity of the rectilinear vibration is very similar to that of the electrostatic E. M. F. due to the action of its two extremities. It should be specially noted that near the centre of the primary the direction is that of the electrostatic E. M. F., showing that it is more powerful than the electro-dynamic, as required by theory.

(2) The lines of force deviate more rapidly from the line A A′ than the electrostatic lines, though this is not so evident on the reduced scale of the diagram as in the author's original drawings on a much larger scale.

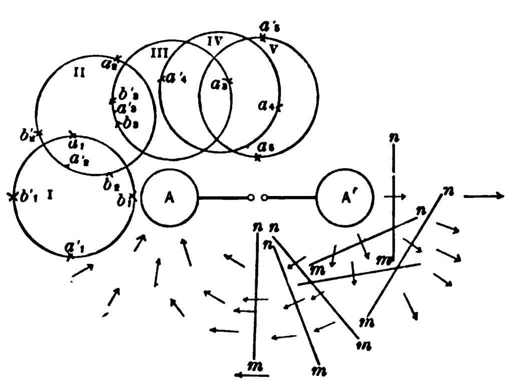

Fig. 8.

It is due to the components of the electrostatic E. M. F. parallel to A A′ being weakened by the E. M. F. of induction, while the perpendicular components remain unaffected.

Experiments with the secondary circuit in a horizontal plane.—The results obtained when the plane of the secondary was horizontal can best be explained by reference to the upper half of the diagram in figure 8.

In the position I, with the centre of the circle in the line A A′ produced, the sparks disappeared when the air space occupied either of the positions b_1 or b'_1, while two equal maxima of the sparking distance were obtained at a_1 and a'_1, the length of the spark in these positions being 2.5 millimeters. Both these results are in accordance with theory.

In the position II, the circle is cut by the electro-magnetic lines of force, and, therefore, a does not vanish. It will, however, be small, and we should expect that the expression $a + \beta \sin \theta$ would have two unequal maxima $\beta + a$ and $\beta - a$, both for $\theta = 90°$, and having the line joining them perpendicular to the resultant E. M. F., and between these two maxima we should expect two points of no sparking near to the smaller maximum. This was confirmed by the observations.

The maximum sparking distances were 3.5 millimeters at a_2 and two millimeters at a'_2. Now with the air space at a_2, the sphere A being positive, the resultant E. M. F. in the opposite portion of the circle will repel positive electricity from A, and therefore tend to make it flow round the circle clockwise. Between the two spheres the electrostatic E. M. F. acts from A towards A′, and the opposite E. M. F. of induction in the neighborhood of the primary acts from A′ to A, parallel to the former, and acting more strongly on the nearer than on the further portion of the secondary, tends to cause a current in the same direction as that due to the former, namely, in a clockwise direction. Thus the resultant E. M. F. is the sum of the two as required by theory, and in the same way it is easily seen that when the air space is at a'_2, the resultant E. M. F. is equal to their difference.

As the position III is gradually approached, the maximum disappears, and the single maximum sparking distance a_3 was found to be four millimeters in length, having opposite to it a point of disappearance a'_3. In this case clearly $a = \beta$, and the sparking distance is given by the expression $a\ (1 + \sin \theta)$. The line $a_3\ a'_3$ is again perpendicular to the resultant E. M. F.

As the circle approaches further towards the centre of A A′ a will become greater than β, and the expression $a + \beta \sin \theta$ will not vanish for any value of θ, but will have a maximum $a + \beta$ and a minimum of $a - \beta$, and in the experiments it was found that the sparks never entirely disappeared, but varied between a maximum and a minimum, as indicated by theory.

In the position IV, a maximum sparking distance of 5.5 millimeters was observed at a_4 and a minimum of 1.5 millimeters at a'_4.

In the position V there was a maximum sparking distance of six millimeters at a_5 and a minimum of 2.5 millimeters at a'_5. In these experiments the air space should be screened off from the primary in the latter positions as well as in the earlier ones, in which it is unavoidable, as otherwise the results would not be comparable.

In passing from the position III to the position V the line $a\ a'$ rapidly turned from its position of parallelism to the primary circuit into a position perpendicular to it. In the latter positions the sparking was essentially due to the inductive action, and therefore the author was justified, in the experiments described in my previous papers, in assuming the effect in these positions to be due to induction.

Even in these positions, however, the sparking is not totally independent of electrostatic action, except when the air space is half way between the maximum and minimum positions, and therefore, $\beta \sin \theta = 0$.

Other positions of the secondary circuit.—Dr. Hertz made numerous observations with the secondary circuit in other positions, but in no case were any phenomena observed which were not completely in accordance with theory. As an example of these consider the following experiment :—

The secondary was first placed in the horizontal plane in the position V (figure 8*), and the air space was in the position a_5 relatively to the primary. The circle was then turned about a horizontal axis through its centre and parallel to the primary, so as to raise the air space above the horizontal plane. During this rotation θ remained equal to 90°, and the value of β remained nearly constant, but a varied approximately in the same ratio as $\cos \Psi$, Ψ being the angle between the plane of the circle and the horizontal, for a is proportional to the number of magnetic lines of force passing through the circle. Let a_0 be the value of a in the initial position, then in the other positions its value would be $a_0 \cos \Psi$, and therefore the sparking distance should be given by the expression $a_0 \cos \Psi$, $+ \beta$, in which a_0 was known to be greater than β. This was confirmed by observation, for it was found that as the

*See *The Electrician*, October 5th, 1888, page 697.

air space increased its height above the horizontal plane the sparking distance diminished from 6 millimeters down to 2 millimeters, its value when the air space was at its greatest distance above the horizontal plane. During the rotation through the next quadrant the sparking distance diminished almost to zero, and then increased to the smaller maximum of 2.5 millimeters, which it attained when the circle had turned through 180°, and was therefore again horizontal. Similar results were obtained in the opposite order, as the circle was rotated from 180° to 360°. When the circle was kept with the air space at its maximum height above the horizontal plane, and then raised or lowered bodily without rotation, the sparking distance was found to diminish in the former case and to increase in the latter, results completely in accordance with theory.

Forces at greater distances.—Experiments with the secondary at greater distances from the primary are of great importance, as the distribution of E. M. F. in the field of an open circuit is very different according to different theories of electro-dynamic action, and the results may, therefore, serve to eliminate some of them as untenable. In making these experiments, however, an unexpected difficulty was encountered, as it was found that at distances of from 1 to 1.5 meters from the primary the maximum and minimum, except in certain positions, became indistinctly defined; but when the distance was increased to upwards of two meters, though the sparks were then very small, the maximum and minimum were found to be very sharply marked when the sparks were observed in the dark. The positions of maximum and minimum were found to occur with the circle in planes at right angles to each other. At considerable distances the sparking diminished very slowly as the distance was increased. Dr. Hertz was not able to determine an upper limit to the distance at which sensible effects took place, but in a room 14 meters by 12, sparks were distinctly observed when the primary was placed in one corner of the room, wherever the secondary was placed. When, however, the primary was slightly displaced, no effects could be observed, even when the secondary was brought considerably nearer. The interposition of solid screens between the two circuits greatly diminished the effect.

Dr. Hertz mapped out the distribution of force throughout the room by means of chalk lines on the floor, putting stars at the points where the direction of the E. M. F. became indeterminate. A portion of the diagram obtained in this manner is shown on a reduced scale in figure 9, with respect to which the following points are noteworthy:—

1. At distances beyond three meters the E. M. F. is everywhere parallel to the primary oscillation. Within this region, therefore, the electrostatic E. M. F. is negligible in comparison with the E. M. F. of induction. Now, all the theories of the mutual action of current elements agree in giving an E. M. F. of induction inversely proportional to the distance, while the electrostatic E. M. F. being due to the differential action of the two extremities of the primary, is approximately inversely proportional to the cube of the distance. Some of these theories, however, are not in accordance with the experimental result that the effect diminishes much more rapidly in the direction of the primary oscillation than in a direction at right angles to it, induced sparks being observed at a distance exceeding 12 meters in the latter direction, while they disappeared at a distance of about four meters in the former direction.

2. That, as already proved, for distances less than one meter the distribution of E. M. F. is practically that of the electrostatic E. M. F.

3. There are two straight lines, at all points of which the direction of the E. M. F. is determinate, namely, the line in which the primary oscillation takes place, and the perpendicular to the primary through its middle point. Along the latter the E. M. F. does not vanish at any point, the sparking diminishes gradually as the distance is increased. This, again, is inconsistent with some of the theories of mutual action of current elements, according to which it should vanish at a certain definite distance. A very important result of the investigation is the demonstration of the existence of regions within which the direction of the E. M. F. becomes indeterminate. These regions form two rings encircling the primary circuit. Since the E. M. F. within them acts very nearly equally in every direction, it must assume different directions in succession, for of course, it cannot act in different directions simultaneously.

The observations, therefore, lead to the conclusion that within these regions the magnitude of the E. M. F. remains very nearly constant, while its direction varies through all the points of the compass at each oscillation. Dr. Hertz states that he has been unable to explain this result, as also the existence of overtones, by means of the simplified theory in which the higher terms of the expansion of F are neglected, and he considers that no theory of simple action at a distance is capable of explaining it. If, however, the electrostatic E. M. F. and the E. M. F. of induction are propagated through space with unequal velocities, it admits of very simple explanation. For within these annular regions the two E. M. F.'s are at right angles and of the same order of magnitude; they will, therefore, in consequence of the distance traversed, differ in phase, and the direction of the resultant will turn through all the points of the compass at each oscillation.

This phenomenon appears to him to be the first indication which has been observed of a finite rate of propagation through space of electrical actions, for if there is a difference in the rate of propagation of the electrostatic and electro-dynamic E. M. F., one at least of them must be finite.

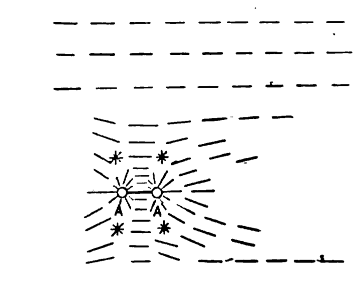

Fig. 9.

At the end of the paper in which the preceding experiments are described Dr. Hertz describes some observations which he has made on the conditions at the primary sparking point which affect the production of sparks in the secondary circuit. He finds that illuminating the primary spark diminishes its power of exciting rapid oscillations, the sparks in the secondary being observed to cease when a piece of magnesium wire was burnt, or an arc lamp lighted, near the primary sparking point. The observed effect on the primary sparks is that they are no longer accompanied by a sharp crackling sound as before. The effect of a second discharge is especially noteworthy, and it was found that the secondary sparks could be made to disappear by bringing an insulated conductor close to the opposed surfaces of the spheres forming the terminals at the primary air space, even when no visible sparking took place between the latter and the insulated conductor. The secondary sparking could also be stopped by placing a fine point close to the primary air space, or by touching one of the opposed surfaces of the terminals with a piece of sealing-wax, glass, or mica. Dr. Hertz states that further experiments have led him to conclude that, even in these cases, the effect is due to light too feeble to be perceived by the eye, arising from a side discharge. He points out that these effects afford another example of the effects of light on electric discharges, which have been observed by E. Wiedemann, H. Ebert, and W. Hallwachs.

Dr. Hertz's next paper in order of publication in Wiedemann's *Annalen*, "On Some Induction Phenomena arising from Electrical Actions in Dielectrics" (Wiedemann's *Annalen*, vol. xxxiv., p. 273), contains an account of some researches undertaken with a view of obtaining direct experimental confirmation of the assumption involved in the most suggestive theory of electrical actions, viz., that of Faraday and Maxwell, that the well-known electrostatic phenomena observed in dielectrics are accompanied by corresponding electro-dynamic actions. The method of observation consisted in placing a secondary conductor adjusted to unison, as regards electrical oscillations, with the primary, as near as possible to the former, and in such a relative position that the sparks in the primary produced no sparking in the secondary. As the equilibrium could be disturbed and sparking induced in the secondary by the approach of conductors, it formed a kind of induction balance; but the point of special interest in connection with it was that a similar effect was produced when the conductors were replaced by insulators, provided the latter were of comparatively large size. The observed rapidity of the oscillations induced in the dielectrics showed that the quantities of electricity in motion under the influence of dielectric polarization were of the same order of magnitude as in the case of metallic conductors.

The apparatus employed is shown diagrammatically in figure 10, and was supported on a light wooden framework,

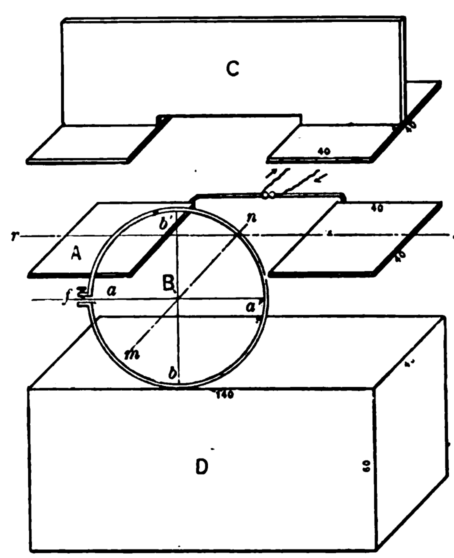

Fig. 10.

not shown in the illustration. The primary conductor consisted of two brass plates, A A', with sides 40 centimeters in length, joined by a copper wire 70 centimeters long and half a centimeter in diameter, containing an air space of three-quarters of a centimeter, with terminals formed of polished brass spheres. When placed in connection with a powerful induction coil, oscillations are set up, the period of which, determined by the dimensions of the primary, can be determined to within a hundredth-millionth of a second. The secondary conductor consisted of a circle, 35 centimeters in radius, of copper wire two millimeters in diameter, containing an air space, the length of which could be varied by means of a screw from a few hundredths of a millimeter, up to several millimeters. The dimensions stated were such as to bring the two conductors into unison, and secondary sparks up to six or seven millimeters in length could be obtained.

The circle was movable about an axis through its centre perpendicular to its plane, to enable the position of the air space to be varied. The axis was fixed in the position *m n* in the plane of A and A', and half-way between them. The centre of the circle was at a distance of 12 centimeters from the nearest points of A and A'.

When *f* was in either of the positions *a* or *a'* lying in the plane of A A' no sparking occurred in the secondary, while maximum sparking took place at *b* and *b'* 90° from the former positions. The E. M. F. giving rise to the secondary sparks is, as in previous experiments, partly electrostatic and partly electro-magnetic, and the former being the greater will determine the sign of the resultant E. M. F. The oscillations must, for the reason previously explained, be considered as produced in the part of the secondary most remote from the air space. Assuming the E. M. F. and the amplitude of the resulting oscillation to be positive when *f* is in position *b'*, they will both be negative when *f* is at *b*.

When the circle was slightly lowered in its own plane the sparking distance was increased at *b'* and diminished at *b*, and the null points lay at a certain distance below *a* and *a'*. The electrostatic E. M. F. is scarcely affected by such a displacement, but the integral of the E. M. F. of induction taken round the circle is no longer zero, and therefore gives rise to an oscillation which will be of positive sign whatever be the position of *f*, for the direction of the resultant E. M. F. of induction is opposite to that of the electrostatic E. M. F. in the upper part of the circle, and coincides with it in the lower half where the electrostatic E. M. F. has been assumed to be positive. Since the new oscillation so produced is in the same phase as the previously existing one their amplitudes must be added to give the resultant amplitude, which explains the phenomena.

Effects of the approach of conductors.—In making these observations it was found necessary to remove all conductors to a considerable distance from the apparatus, in order to obtain a complete disappearance of sparking at the points *a* and *a'*. Even the neighborhood of the observer was sufficient to set up sparking when the air space *f* was in either of these positions, and the sparks had therefore to be observed from a distance. The conductors used for the experiments was of the form shown at C (figure 10), and consisted of thin metal foil. The objects kept in view in selecting the material and dimensions were to obtain a conductor which would give a moderately large effect, and having an oscillation period less than that of the primary.

When the conductor C was brought near to A A', it was found that the sparking distance decreased at *b* and increased at *b'*, and the null points were displaced upwards—that is, in the direction of C.

From the results of experiments already described it is evident that the effect of displacing A A' upwards would be the same, qualitatively, as that of a current in the same direction as that in A A' directly above it. The effect produced by the approach of C was the reverse of this, and could be explained by an inductive action, supposing there were a current in C in the opposite direction to that in A A', which is exactly what must occur; for the electrostatic E. M. F. would give rise to such a current, and since the oscillations in C are more rapid than those of this E. M. F., the current must be in the same phase as the inducing E. M. F. The truth of this explanation was confirmed by the following experiments. The horizontal plates of the conductor C being left in the same position as before, the vertical plate was removed, and successively replaced by wires of increasing length and fineness, in order to lengthen the oscillation period of C. The effect of this was to displace the null points more and more in an upward direction, while at the same time they became less sharply defined, a minimum sparking taking the place of the previous absolute disappearance. The sparking distance at the highest point had previously been much less than at the lowest point, but after the disappearance of the null points it began to increase. At a certain stage the sparking distance at the two positions became equal, and then no definite minimum points could be found, but sparking took place freely at all positions of *f*. Beyond this stage the sparking distance at the lowest point diminished, and very

soon two minimum points made their appearance close to it, not clearly defined at first, but gradually becoming more distinct, and at the same time approaching the points a a', with which they ultimately coincided, when the minimum points again became absolute null points. As the oscillation period of C approaches that of A A′, the intensity of the current in the former increases, but a difference of phase arises between it and the exciting E. M. F. When the two are in unison the current in C attains its maximum, and, as in other cases of resonance, the difference of phase gives rise to a slightly damped oscillation, having a period of about a quarter that of the original one, which makes any interference between the oscillations excited in the circle B by A A′ and C respectively impossible. These conditions clearly correspond to the stage at which the sparking distances at b and b' were equal. When the oscillation period of C becomes decidedly greater than that of A A′, the amplitude of the oscillation in the former will again diminish, so that the difference in phase between it and the exciting E. M. F. will approach half of the original period. The current in C will therefore always be in the same direction as that in A A′, so that interference between the two oscillations excited in B will again become possible, and the effect of C will then be opposite to its original effect. When the conductor C was made to approach A A′ the sparks in B became much smaller, which is explained by the fact that its effect will be to increase the oscillation period of A A′, and therefore to throw it out of unison with B.

(*To be continued.*)

THE WESTERN ELECTRIC INCANDESCENT LIGHTING SYSTEM.

The Western Electric Company, of Chicago, New York, London and Antwerp, whose venture into the field of electric lighting with its arc system a few years ago has proved so successful, have introduced recently an incandescent lighting system of their own design and manufacture, which possesses several new and interesting features.

The type of field magnet frame used in their now familiar arc lighting dynamo is not used in the construction of their incandescent lighting machine, a simpler form, and one better adapted to this class of work, having been adopted.

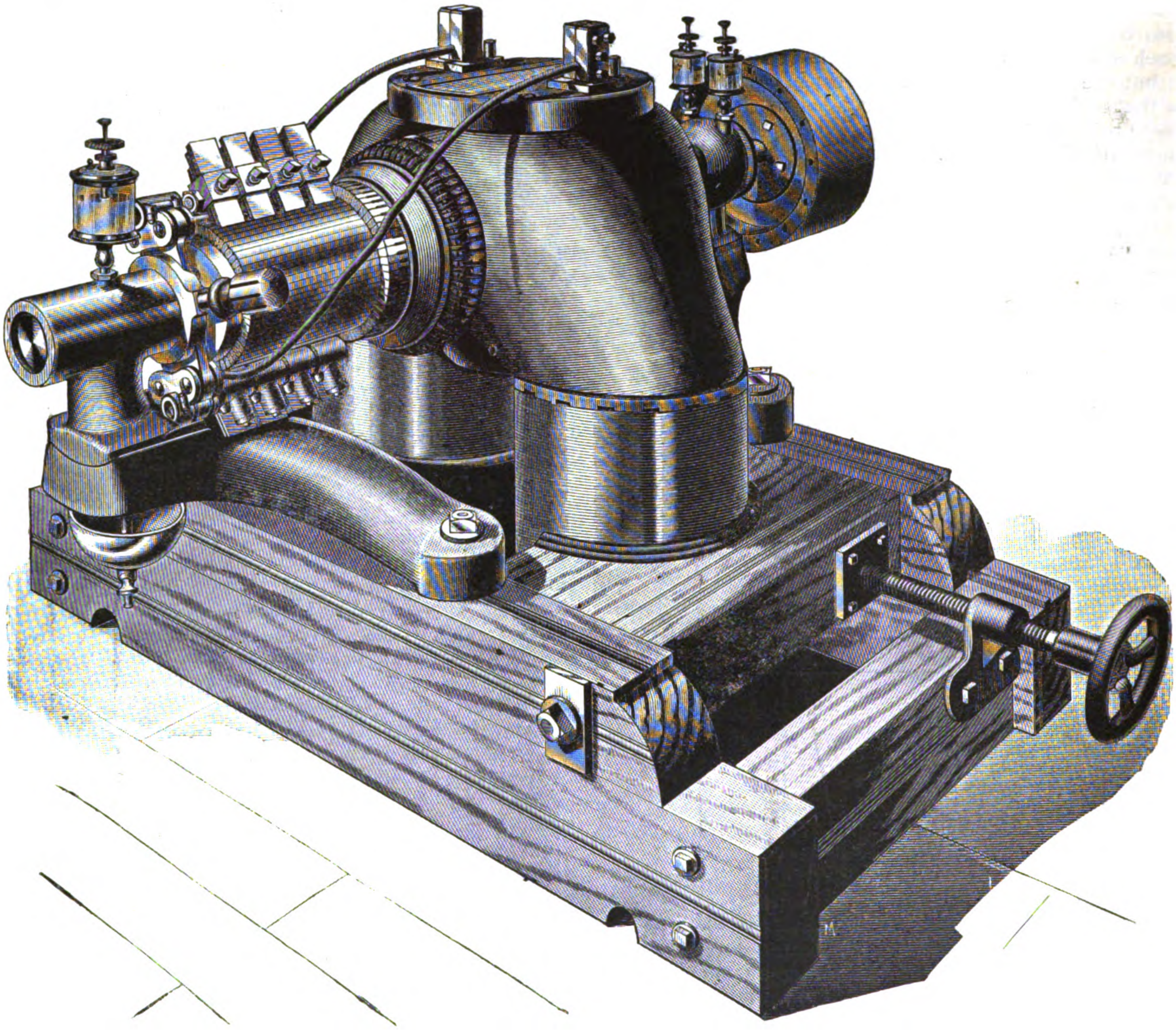

Fig. 1.—Western Electric Incandescent Dynamo.

Figure 1 illustrates a complete dynamo, while figure 2 shows a field magnet, pole-pieces and frame only. The whole iron base is cast in one piece. The cores of the field magnets are made of soft iron and the pole-pieces are cast upon the upper ends of the cores. The lower ends of the cores are bolted to the cast-iron base. There are, therefore, only two magnetic joints in the whole field system. The field magnet coils are connected in shunt with the armature. The automatic regulation thus secured is found to be practically perfect. Any number of lamps may be cut in or out without visibly affecting the candle-power or brilliancy of the remaining lamps throughout a circuit. The armature is of the drum type, and is wound in a simple and peculiar way, avoiding all joints in the wires but two. The electrical and commercial efficiency of the dynamo is said

to be very high, while in its mechanical construction and workmanship it is quite up to or above the average practice of the day. The machine is provided with a self-adjusting bearing on the pulley side.

The peculiar form of the cast-iron base and the manner in which it is inserted and secured in the wooden carriage, result in bringing the armature shaft at a convenient height from the floor—but not so high as is usually the

FIG. 2.—Western Electric Incandescent Dynamo. Frame, Field Magnets and Pole-Pieces.

case in dynamos having this type of field magnet—while at the same time it permits the use of the sliding carriage for adjusting belt tension without raising the dynamo so high as to render it unstable. On the top of the pole-

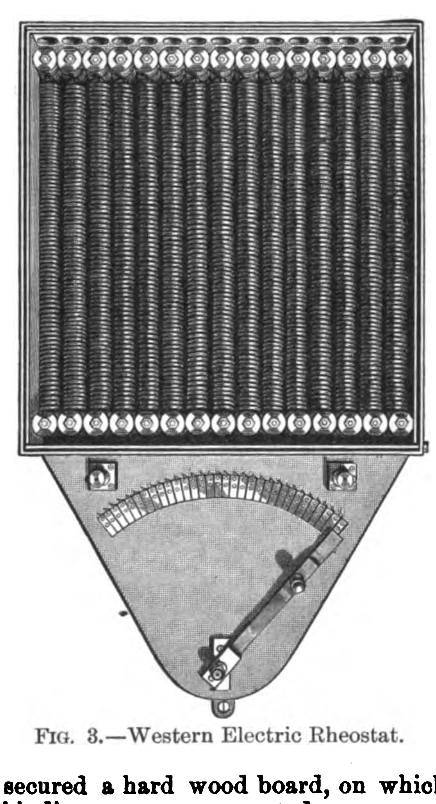

FIG. 3.—Western Electric Rheostat.

pieces is secured a hard wood board, on which the field and main binding posts are mounted.

The rheostat, figure 3, is non-combustible. It consists of a cast-iron frame provided with porcelain insulators, to which the german-silver wire coils are attached. The front of the rheostat box is covered with glass, preventing dirt and dust from getting into the box and at the same time allowing ready inspection.

Figures 4 and 5 represent the voltmeter and ammeter. These instruments are dead beat, and may be left in the circuit permanently without overheating.

The lightning arrester is very simple in its operation and requires no automatic cut-outs or safety strips for the prevention of short circuits. The jaws of

FIG. 4.—Western Electric Voltmeter.

this lightning arrester are made of carbon plates. In case the dynamo current should follow a discharge of atmospheric electricity an arc may be set up, but this will burn away the carbon points and thus free the dynamo of the short circuit. Such a carbon lightning arrester can, of course, only be used for low tension dynamos.

A multiple safety cut-out board is used where wires are run to central distributing points, which are located in closets. All the safety devices are provided with glass covers to keep out dust and at the same time allow of easy inspection.

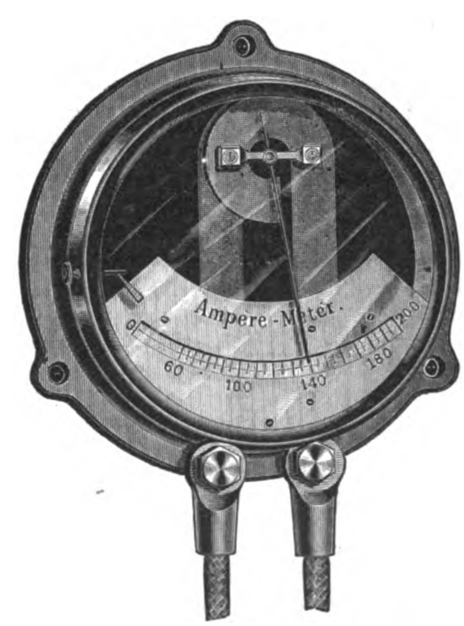

FIG. 5.—Western Electric Ammeter.

Every feature of an isolated incandescent lighting outfit has been fully provided for and the whole system is carefully worked out to the smallest details. Particular attention has been given to securing simplicity of design and excellence of workmanship.

The ample resources of the Western Electric Co. and its extended experience in general electrical manufacturing, together with its acquired practice in arc lighting machinery supplemented by the services of electricians skilled in incandescent lighting, who have recently been added to its staff, have been brought to bear for the purpose of producing apparatus of the best design and construction and of high efficiency.

ABSTRACTS AND EXTRACTS.

THE INSTITUTION OF ELECTRICAL ENGINEERS.[1]

Sir William Thomson's Inaugural Address.

For more than one reason the meeting of this Institution, held on the 10th inst. [January, 1889], was of special interest. It was the first meeting which the Society held after officially assuming its new name; it was a meeting at which the new president, Sir William Thomson, delivered his inaugural address, and the attendance was larger than we have ever known it to be before. * * * * After some formal business, including the readjustment of prizes, which was necessitated by the generous offer of Professor Silvanus Thompson to forego the first prize awarded to him for his paper on influence machines in favor of some younger member of the Institution, the retiring president, Mr. Graves, vacated the chair, which was then occupied by Sir William Thomson, who delivered his inaugural address. The title of the address was "Ether, Electricity, and Ponderable Matter,"and the subject being one which has occupied the most profound thinkers of the old and new world for over a generation, and especially Sir William Thomson for the last forty years, it will be readily understood that his address was of absorbing interest, and we give a brief abstract of it.

The president began by reminding his hearers that when he occupied the presidential chair fourteen years ago the Society was in the third year of its existence, and contained only 570 members, which number had now increased to 1550. He pointed out that the Society owed its origin mainly to Sir William Siemens, and alluded with regret to the numbers who had passed away since its foundation. Among these were the two first presidents, Sir William Siemens and Mr. Frank Scudamore, and three later presidents—Mr. Walker, Colonel Champney, and Sir Charles Bright, his colleague in the laying of the first Atlantic cable in 1857. The Society, originally founded as the "Society of Telegraph Engineers," had grown in scope as well as in numbers, as shown by its successive changes of title—first to "Society of Telegraph Engineers and Electricians," and finally to "Institution of Electrical Engineers." At its first foundation, the only electrical industries were telegraphy and electro-metallurgy. To these there had now been added telephony, the electrical transmission of power, electric haulage, applications to naval and military operations, and last, but not least, electric lighting. Referring to the connection between electrical and civil engineering, Sir William pointed out that in his presidential address of fourteen years ago he had called attention to the great mistake made by architects in not being at the same time engineers. Electrical engineers, however, were not open to a similar reproach, as they were fully alive to the essential necessity of being engineers before they become electricians. The idea was a great deal too prevalent that a mere taste for electricity was an indication of the fitness of a youth for the profession of an electrical engineer, and it was therefore most necessary to insist upon the fact that electrical engineering was not confined to electricity and ether, but had to deal with ponderable matter as well; and the aspirant to the profession, after having received a good general education, must obtain a competent knowledge of mathematics and dynamics, and should be thoroughly trained in the principles of mechanical and civil engineering. The requisite knowledge of electricity for a commencement could then be acquired in a short time, but he must be prepared to be ever learning and extending his knowledge of electrical phenomena throughout the whole of his professional career.

Turning, after these introductory remarks, to the immediate subject of his address, the president remarked that the demand for some kind of mechanical explanation of electrical phenomena was not new, but was now growing in intensity. With regard to the gradual growth of the demand, he referred to some of the past presidential addresses, and the first who called attention to the subject in this manner was Mr. Preece, who, in his presidential address in 1883, dwelt on the relations which Maxwell had shown to exist between electricity and light; while on a subsequent occasion Mr. Willoughby Smith had briefly referred to some very interesting experiments of his own upon the screening effects of sheets of different metals upon electromagnetic induction, or, perhaps, he ought to say, electrical induction, as it was fast becoming impossible to specially differentiate induction. The mathematical theory of these phenomena had been very ably worked out by Horace Lamb and W. D. Niven. In a still later address, Professor Hughes had described his wonderfully interesting experiments on induction, and though the forms in which some of his statements were cast were criticised from the mathematical point of view, even these statements, by giving rise to such criticism, had afforded a powerful stimulus to the advance of our knowledge of the subject.

One of the first problems in electrical induction which was worked out in detail, arose in submarine telegraphy. The researches of Henry and Faraday had given us a general knowledge of the phenomena of electro-magnetic induction between two wires. The electro-static induction due to the Leyden jar discharge was also explained by Faraday, who laid the foundation for all the subsequent advances in the knowledge of this phenomenon, by showing that the conduction of a charge through the wire necessarily raised its potential by a definite amount above that of the earth. Cromwell Varley had developed Faraday's work in several important points, while Stokes and the speaker had mathematically worked out the theory of induction in cables. The mathematical investigations showed that in the case of cables of more than two hundred or three hundred miles in length, the speed of working was so limited by electro-static induction, that the electro-magnetic induction could not possibly produce any appreciable effect, and it was therefore omitted entirely from the theory. This would not be the case if the cable were only fifty miles in length. The speaker had partly worked out this question in order to test the range of applicability of the theory which only took account of the electro-static induction; and the question was further brought into notice by Werner and Charles Siemens, when laying their Mediterranean cables. Then the electro-magnetic induction was considered the most important; but the speaker found that its effect would be absolutely imperceptible, and in consequence of the result of his investigation, Messrs. Siemens abandoned their proposed plan of forming the conductor of two thin wires close together, as this arrangement would have increased the electro-static induction, which was the important factor. The question had now again come to the front, and Mr. Oliver Heaviside had worked it out very completely. Heaviside had pointed out that the electro-magnetic induction instead of being harmful, was actually beneficial, having the same effect as that of mass in such a case as a boat running upon wheels in a viscous fluid. If impulsive forces were applied to two such boats of different masses, the one of greater mass would require a greater

1. From *Industries*.

force to set it in motion; but when once in motion it would go further. In the same way, when the electro-magnetic induction was considerable, greater electric force, so to speak, was required to set the current in motion; but once started, it would travel further. Heaviside had brought into prominence the well-known fact that the effect of a leak in a cable is in itself beneficial, and if it could be kept constant, and prevented from introducing earth currents, it would increase the distinctness of the signals. The distinctness of the signals did not depend so much on the amplitude of the current wave, or on the increase of potential at the remote end, as on the retardation of the phase, though the diminution of amplitude with increasing distance had to be considered as well. If the variations of each of these were constant throughout the length of the cable, then perfect distinctness of signals would result. In the case of transmission of sound, the retardation of phase, and the diminution of intensity with the distance, being the same for all notes, there was no loss of clearness with increasing distance. Heaviside had shown that the effect of electro-magnetic induction was to diminish the difference in phase, tending to make it the same throughout, and Sir William pointed out that the retardation of electrical waves was exactly similar to that of light waves. These developments in the theory were of great practical value, as in the case of telephonic currents the frequency varied from 256 alternations a second up to as much as four times that amount, and with these high frequences the electro-magnetic induction became perceptible, and there was no doubt that the clearness with which sound was transmitted by the telephone was due in great part to the fact that the high frequency of alternation greatly diminished the differences in the alternation of different notes. Sir William then went on to consider the relative advantages of iron and copper as telephonic conductors, and stated that information which he had received from Mr. Bennett, the engineer of the National Telephone Company of Scotland, established beyond a doubt that the articulation was much less distinct when iron wires were used as conductors, than with copper wires of equal resistance. In all probability the investigations by Mr. Oliver Heaviside, and by Lord Rayleigh, into the susceptibility of iron to small differences in magnetic force, would lead to a complete explanation of this fact. The speaker had worked out some numerical results in the problem of the transmission of alternating currents through telephonic or electric light conductors. The calculations had to be made by the aid of Bessel's Functions, a modified form of Laplace's Functions, or Spherical Harmonics, suitable for treating the problem of the variation of the potential at the ends of an infinitely long cylindrical copper wire, or for its treatment in the case of an infinitely long copper wire surrounded by a concentric cylindrical copper conductor, or of two infinitely long parallel copper wires. The latter problem was as easy as that of the wire and concentric tubular conductor, provided the distance between the two wires was great enough to prevent the current in one from influencing the distribution of current throughout the interior of the other, as in this case the disturbance was independent of the surroundings. This condition would be fulfilled in the cases occurring in practical telegraphy. Assuming a frequency of eighty alternations a second, which was about the frequency adopted in the current supplied from the Grosvenor Gallery installation, he found that in the case of a copper wire 2 centimeters in diameter the ohmic resistance was 8 per cent. more for the alternating current than for a direct current, 63 per cent greater for a wire 4 centimeters in diameter, four times as great for a wire 10 centimeters in diameter, and seventeen times as great for a wire 100 centimeters in diameter. When the diameter exceeded 10 centimeters, the ohmic resistance, that is, the reciprocal of the ohmic resistance, increased sensibly in direct proportion to the circumference, and not in proportion to the square of the diameter. For smaller diameters the relation was much more complicated, and could only be expressed in terms of Bessel's Functions. The numbers applying to a wire of given diameter, with a given rate of alternation, would be the same for a wire of half the diameter, provided the frequency were four times as great. Thus for a frequency of 320 alternations a second, a copper telephone wire 1 centimeter in diameter would have an ohmic resistance 8 per cent. greater than for a steady current; for a diameter of two centimeters, the ohmic resistance would be 63 per cent. greater, and so on. The conductivity of the wire was therefore of much less importance in the case of telephone wires than in the case of electric light wires; for if the frequency were sufficient to greatly increase the ohmic resistance, the current would be proportional to the reciprocal of the square root of the resistance, instead of to the reciprocal of the resistance, as in the case of a steady current. The diameter of a telephone wire should therefore be chosen so as not to increase the ohmic resistance to such an extent as to sensibly disturb the uniformity of distribution. Sir William pointed out that the equations of motion of a viscous fluid which were first given by Professor Stokes were identical with those which determined the distribution of current in a conductor, and therefore there was an exact analogy between the two cases; and as Heaviside had pointed out, this analogy was most helpful, because it was comparatively easy to form a mental image of the phenomena in the fluid, but impossible to do so in the electrical problem. Thus a cylindrical copper wire, carrying an alternating current, might be compared to a cylindrical tube of infinite length (or the tube might be of great length in comparison with its diameter, and fitted with frictionless pistons at its extremities, and the portion of fluid considered should be at a distance of many diameters from the ends), containing a viscous fluid, and moved to and fro with a simple harmonic motion. If the fluid were non-viscous, no motion would be produced in it by the motion of the tube; but if viscous, the alternate motion would penetrate inwards from the surface, just as in the case of the current in the wire. Another analogy might be found by considering a cylindrical conducting solid, embedded in some substance such as rock, subject to variation in temperature. The penetration of maxima, minima, and zero temperatures into the cylinder would then follow the same law as the penetration of motion into the fluid, or of electric current into the wire.

Another case in which the viscous fluid analogy held good, though the thermal one broke down, was that of the penetration of an induced current into the copper core of a solenoid. This might be compared with the penetration of motion into a viscous fluid contained in a tube rotated with varying velocity; and the speaker pointed out that if the penetration were very small, it would follow the same law as in the case of the tube being moved longitudinally to and fro. In the case of iron cores, the complications introduced by the variation in the magnetic susceptibility with the strength of the magnetic induction were so great that the problem was at present completely beyond the power of mathematical analysis.

The case of two parallel wires carrying alternate currents could be represented by alternate rotations in opposite directions, density would correspond to resistance, and a change of density would correspond to a change of one metal to another; while an insulator would be represented by a viscous fluid devoid of inertia. The electro-static effect could be represented by introducing a change of phase, and giving a certain amount of stiffness to the fluid, and the analogy could be extended to the case of a submarine cable by the introduction of an arbitrary normal force at the surface; but though a perfect mathematical analogy, and therefore of great help in the mathematical treatment of the subject, the analogy could not be considered in any sense a physical one, owing to the arbitrary character of the force introduced. Sir William also pointed

out that the analogue of an electric current was not a molecular rotation of the fluid, but in Maxwell's terminology the rotation of the vector representing the velocity of the fluid at any point, that is to say, the vector portion of the quantity obtained by operating on this vector by Laplace's operator. Clifford called this quantity the "curl" of the vector, and Sir William regretted that Heaviside had adopted the term, as he preferred the term "rotation." The analogue of a steady current was obtained by pressing in the piston at one end, when the motion, though disturbed in the neighborhood of the piston by the rigidity of the latter, would be quite regular at a distance of say 20 diameters. The velocity would be a maximum at the centre of the tube, and zero at the surface. Taking a longitudinal section through the axis of the tube, the particles of fluid originally lying along a transversal perpendicular to the sides of the section would lie upon a curve of parabolic form, and there were then two things to be considered to determine the motion, viz.: the rate of shearing, and the rate of change in the rate of shearing per unit of distance from the surface of the tube. The latter quantity, which was the analogue of the velocity of the current, was measured by the tangent of the angle of inclination to the transversal of the tangent to the parabolic curve at the point considered.

Sir William then went on to observe that he believed that an electric current actually caused a rotation in the ether, and considered the case of a helix surrounding a copper core. Induced currents were set up in the copper, and the only action conceivable in the space included between the helix and the core was a rotation. This might be either a continuous rotation or a rotation through an angle proportional to the strength of the current. In iron, however, something quite different must take place. If the fluid moved round continuously, there would be no shearing; if, on the other hand, there were only a drag upon the ether through a certain angle, then there must be a force resisting steady rotation—that is to say, there would have to be an arrangement of matter of such a character that a constant torque would produce a constant, instead of an accelerated, rotation. It would appear that such an effect could only be produced by an inherent rotation of the molecules. Sir William proceeded to show that it was quite possible to form a conception of a medium of the kind required. For imagine a number of squares, with their sides parallel, fixed together with elastic bands, and suppose each square to contain a gyrostat in the form of a rotating molecule. Then one of these squares could only be turned out of its plane by the application of a minimum torque equal to the time integral of the moment of inertia of the gyrostat. Such a medium without the gyrostats would have the properties of a perfect liquid; but with the gyrostats in place, turning could only take place by stretching the elastic bands, which would require a constant torque. While pointing out that this was a very gross illustration, he thought it of value, as the mere fact that they could conceive of such a mechanism might be considered as indicating that a mechanism having these properties, though not at all resembling our conception, might actually exist in nature. On this hypothesis the observed phenomena would indicate that the ether must be less rigid in iron than in other metals, and have the same value for all non-magnetic metals. In iron, therefore, the velocity of the rotating molecules would have to be less than in other substances. In concluding, Sir William pointed out that even the very imperfect attempts at a mechanical explanation of electrical phenomena which he had indicated would only apply to very small parts of the subject, and the tremendous difficulties in the way of a complete mechanical explanation prevented him from hoping to see the question solved in his own lifetime, though he felt confident that a solution would be found, and that what appeared so insuperable a mystery to us would be no mystery at all to future generations. At the conclusion of his address Sir William exhibited some very interesting experiments with a large gyrostat, in illustration of the properties which he had assumed in the construction of the ether.

THE HAMBURG ELECTRIC LIGHTING STATION.[1]

This station, although built for the immediate supplying of 12,000 16 c. p. lamps, has an extension ready to meet an anticipated call for double that number. The two-wire system is employed. The entire 12,000 lamps, can, if necessary, be supplied with current at the same time. The plant includes a dynamo to supply 67,000 volt amperes; and five dynamos, each supplying 134,000 volt amperes. The small dynamo, and one of the larger ones are each connected with a separate steam engine, while the remaining four are driven in pairs by two engines. The engines are of the vertical, compound type, with condensers. The dynamos are Schuckert's flat ring machines, which at 300 revolutions give the above-named output of 67,000 and 134,000 volt amperes respectively.

The whole consumption is furnished through 18 principal circuits, of which two run to the theatre. The fall of potential for the full consumption of 12,000 lamps, is 15 volts in the principal wires, and 1.5 volts in the branch circuits. The combined length of wire is 30 kilometers (18.6 miles), and the greatest distance from station 900 meters (0.56 miles). The conductors, which are cables with double lead covering, are bedded in U-iron ducts decked with iron plates. The principal conductors terminate in iron boxes divided into compartments in which the cables lie, surrounded by an insulating substance. Each principal cable contains two testing wires, for the controlling, regulating and signaling apparatus. Any increase beyond the present consumption is to be met by the addition of other conductors, for which purpose the U-iron troughs are made of sufficiently large dimensions. For the extension of conductors beyond their present territory, it is proposed to employ the three-wire system, laying additional conductors for use in connection with the two-wire conductors now in service. Points lying very far from the central station are to be supplied with indirect current by means of continuous current transformers or accumulators.

DISCUSSION ON LIGHTNING CONDUCTORS AT THE BRITISH ASSOCIATION.[1]

(Concluded from page 179.)

Mr. Walker, Sen., having made some remarks on the striking of an obelisk which he had witnessed,

Mr. Trueman Wood said that the dark flash before referred to could not be due to over-exposure, because the white one, which was presumably, according to that theory, less exposed, overrode the black. He considered that the black flash was evidently produced by tralation, or reflection from the back surface of the glass plate.

The President then called upon Lord Rayleigh, Professor Lodge, and Mr. Preece to reply.

Lord Rayleigh said that Professor Stokes had once made a suggestion that, he believed, had never been published, to the effect that it was possible for the black flashes, which he (the speaker) thought, with Mr. Trueman Wood, were evidently not caused by over-exposure, to be accounted for in the following way. Professor Stokes thought that, under the influence of a lightning flash, the atmospheric gases—oxygen and nitrogen—were combined so as to produce considerable quantities of the oxides of nitrogen; that those oxides of nitrogen, formed along the line of the flash, were opaque to the invisible rays at the upper limit of the spectrum to which most of the photographic action was due; and that this, when another flash occurred, illuminating the background of the cloud, would darken the place where the first flash had been. Hence the mark of the flash would appear as a black line, on account of its opacity to the general first light of the background.

Professor Oliver Lodge said that so many things had been remarked, and so much might be said on points which had not

1. From the *Electrotechnische Zeitschrift*, March, 1889.

1. From *Industries*, November 23, 1888.

been commented upon, that one must exercise selection in what one mentioned. Mr. Walker, Mr. Symons, and Mr. Preece, too, spoke as if he had specially attacked the report of the conference. But that he had not done at all; he had made great use of the report, and he thought that that conference had done a very valuable piece of work. They had collected together all manner of details of destructions and of failures of lightning rods. The whole of the report is bristling with failures of lightning rods, so that he was at a loss to understand—no, he did understand—how they could say that rods never fail. They say that a properly constructed lightning rod never fails, because whenever a thing fails they always say there was something the matter with it. They generally say bad earth, but why a thing ought to have such extraordinary good earth he never could tell. What was the difference between one end of the conductor and the other? You stick three points at one end, and you want a lot of roots at the other end; suppose it were upside down, why not have the roots in the sky and the points down below? Why should one end have to be treated so very carefully, and the other end be left to itself? So far as protection is concerned, the points at the top and the three points at the bottom ought to do equally well. Of course it may be inconvenient to have the ground ploughed up, and things of that sort. You ought therefore to have a good deep earth; but, even if they had no earth, a flash ought not to split off from the conductor to such things as safes and gun barrels and rain water gutters. It did that because it met with obstruction—impedance—he did not care what they called it—a spurious resistance. They might call it resistance if they liked, but it was not what they ordinarily called resistance, it was like inertia. As regarded failures of properly constructed lightning conductors, he wanted to know from Mr. Symons—there would be plenty of opportunities for continuing this discussion in print—why the Hotel de Ville, at Brussels, was set on fire by a lightning flash, because if anything was well protected, according to orthodox principles, that building was so. He himself thought it was protected. When he said that a building was not completely safe, he did not mean, and had never thought of meaning, that lightning protectors are of no use; they are of very much use, but they may, and he believed do, occasionally fail. M. de Fonvielle referred to the great experience that Mr. Preece had had, and also to the experience gained in France of all sorts of conductors, telegraph posts, and things like that. It is true they did not fail much, but then a telegraph post, and an obelisk, and a lighthouse were the easiest possible things to protect. There was just one column, and if they stuck one conductor down there was not much chance of its spitting or doing much damage. It was not so easy to protect powder magazines or houses where there was escaping gas. If the lightning flash was only a little bit away from a leaden gas pipe, it would very likely fuse it and light the gas, and they would have the house burnt. Professor Forbes had asked him to say why he did not use one pair of knobs instead of two pairs of knobs to try the experiment. If Professor Forbes tried it with one pair of knobs, he would find that he could not do it at all. There must be two pairs of knobs somewhere. The speaker sketched the two knobs of a Holtz machine, and a supposed alternative path, and then asked somewhat pertinently how were they to get sparks between these knobs? If they were to put an alternative path to an air space, they must have another air space somewhere to enable them to do it, but it need not be done exactly as he had done it. He would not go further into that point now, as the discussion could be continued in print; but he might put his views briefly thus: These discharges are oscillating currents of extraordinarily great frequency—something like a million a second. For these currents it is only the outer surface of a rod that conducts; therefore its obstruction was due to the space surrounding the conductor, and it was not due to the material of the conductor. It is only the outside tube of the conductor that conveys any current, and therefore the conductor, whether iron or copper, did not get magnetized at all. It did not matter about its permeability, or about its conductivity much. The current is very great; even from an ordinary Leyden jar the current produced when discharged through an ordinary togs is about 3,000 amperes. The current in a lightning flash is, no doubt, enormous—he thought a million amperes for the time lasted. That it was very great was shown by the heating powers and the destructive powers it had, though its duration is so extremely small; and hence it is that the impedance being also very great they had this large amount of resistance and a tremendous current, and so they got a tremendous difference of potential at the end and the liability to spit off. Seeing that only the outer surface conducts, what is the good of the inside of the rod? It may be able to conduct some heat away, and so prevent melting, or it may not have time to do that. Probably there is no very great good in it, but if they were going to have a tube they had better have it spread out flat; or better still, have a strand of separated wires, or a series of wires about the size of telegraph wires. That was his view, but it was not authoritative. If what he said would be authoritative, and would go forth as a statement from that room, of course he would hold his tongue; but as it was, he simply said that which he thought true at the time. It was found that all the failures in the case of lightning conductors were due to the spitting off from them; were due to this high potential; were due to the impedance of the conductor—the obstruction of it; to the fact that it does not conduct easily away as they would expect—*not* due to the melting of it. Mr. Symons, in his report of the Lightning Rod Conference, gave a list of conductors which had been melted by the flash, and he apologized for the shortness of the list. No apology was necessary—the list was short because they very seldom got melted. If they analyzed those which Mr. Symons gave, they would find in every case but one that it was only the upper terminals which had been melted, not the full length of the conductor. There was only one case of complete destruction, and that was a bell wire, and, even so, it exerted a protective influence. So, then, we learn that when they are bell wires they are melted; but he did not want the wires which were to be put up to be of the thinness of bell wires. Iron buildings, as Sir William Thomson said, are practically safe for powder magazines, and the safest things they could make; but even with them some little care was wanted. The iron must be in absolutely good connection all through. If there were a gap left anywhere, there might be a spark in that gap. It might be only half an inch long or a quarter of an inch long; that would be quite sufficient to light gas and do all the damage. With regard to the action of sound waves in facilitating the discharge, he might just refer to an experiment first made by Dr. Guthrie, in which a resonant tube was taken, and the interior sprinkled with sand. An electric discharge occurring near the mouth of the tube, it was found that the sand was thrown into ripples, indicating that a series of longitudinal waves had traversed the tube—waves only about one millimeter long. These sound waves were due no doubt to the oscillating heat of the spark, and might certainly, as Sir William Thomson had suggested, precipitate a discharge in the neighborhood; but probably there were also other causes.

Mr. Preece commenced his reply by referring to the remarks which he had made with regard to mathematicians, and which had been so much criticised during the discussion. He explained that he would be far from wishing to undervalue the work of such mathematicians as were sure of their preliminary ground before they thrust their deductions upon the world. His remarks on this subject had really been introduced to try and check a kind of thing that had lately been growing to a very serious extent. Innumerable students had of late years been sent forth by our technical schools, and every year they found some of them armed with a smattering of mathematics, writing papers to our technical journals, in which they thrust upon the scientific (particularly the electrical) world conditions and conclusions arrived at by their mathematics, with a coolness and effrontery that were simply appalling. The true mathematician would never come to a conclusion, and never thrust his conclusions upon the world, unless he were sure of his ground; but the imperfectly trained gentlemen were too fond of throwing out conclusions without the least confirmation by experiment or anything else. As regarded the question of iron and copper, in answer to Sir William Thomson, he would say that most—in fact, all—of those lightning conductors of which he had actual experience were of iron, and always had been, as most of them knew who had read the reports he had written. He was a great advocate of iron. He thought the use of copper to the extent that it was used, introduced a needless expense into the erection of lightning conductors. His own impression was that every private house could be thoroughly protected according to the recommendations of the Lightning Rod Conference for at least a pound. Anybody could buy a coil of stranded iron rope, and if they took an iron rod about a quarter of an inch in diameter, with the finial Mr. Symons had referred to, he believed that they could safely protect their houses with lightning protectors for a few shillings, instead of now where copper was employed, indulging in the expenditure of a few pounds.

The President, having expressed the pleasure with which he, and he felt sure all, had listened to the debate, and having thanked Dr. Lodge and Mr. Preece for their part in it, said that he felt that it would be extremely important, if telephony were to become useful on a very large scale, to protect those using the instruments from the injurious effects of a thunderstorm perhaps far away. He was inclined to believe that the experiment that Dr. Lodge had performed was not exactly analogous to the lightning discharge. As Mr. Preece had said, the discharge was much more like the breaking down of the plates of a condenser. There was a question with respect to the alternation of currents. He would call Mr. Preece's attention to this, that even though there might not be millions of alternations per second, a great many of the effects of an alternating current would be produced by an extremely sudden current of very short duration—that the effects that had been observed were due to the very sudden change in the strength of the current. Now, the effects of a very sudden change in the strength of the current could be produced by a single spark, whether there was an alternation or not. So that a great number of the effects that Professor Lodge had observed, and in reference to which he seemed to think it was necessary to have an alternation several million times a second, would be

produced by a single sudden discharge of a millionth of a second. In conclusion, he considered it desirable that a very large number of conductors should be erected all over the country, and their presence would, no doubt, prevent to a large extent the occurrence of formidable thunderstorms.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Inquiry into the Madison Square Explosions.—Overhead Wires Coming Down; the Mayor and Board of Electrical Control begin to Chop.—Bids for City Lighting.—Collapse of the Callender Insulating and Waterproofing Co.

THE events of the past month have been of unusual interest to those directly and indirectly concerned in electrical industries. It has long been evident that New York is to be the battle ground of the overhead wire war, and the experiences of the metropolis will be taken as a criterion for the framing of laws and regulations by other municipalities.

Immediately after the explosion in the subway at Madison square, a month ago—the Mayor convened the Board of Electrical Control and invited the representatives of the gas companies to attend. In the course of the proceedings it was shown that the leakage in the gas mains averaged from 15 to 20 per cent., and this loss, besides fouling the atmosphere and causing explosions, must be paid for by the consumer.

An engineer from Pittsburgh stated that this leakage was due to the fact that the old gas companies used cast iron pipe with plug and solder joints, while the best construction is that used for all new work—wrought iron pipe with screw joints; but the enormous cost of placing new pipes for the 1,080 miles of gas mains on Manhattan Island is such that the gas companies find it more pleasing to the stockholders to repair leaks as they occur and substitute modern pipe whenever convenient.

Shortly after this meeting the Mayor called for information for the purpose of issuing orders to the Bureau of Incumbrances to remove poles and wires from the streets, when, greatly to the surprise of everybody, the Western Union Telegraph Co. secured the order from Judge Wallace of the United States Circuit Court (mentioned in the ELECTRICAL ENGINEER, for April) temporarily prohibiting interference by the Mayor and Board of Electrical Control, until argument could be heard upon a motion for a permanent injunction. The Western Union had remained passive for some time and such precipitate action was alarming because unexpected. Upon the hearing for an injunction, however, Judge Wallace vacated his previous order in so far as it related to the wires and poles in the streets, holding that all companies owning wires and poles in the streets are subject to reasonable police regulations of the state, and he holds that the laws with regard to the subways are just and reasonable. He ruled, however that the city had no control over the placing of wires and cables upon the elevated railroad structures. (An abstract of Judge Wallace's opinion will be found in this issue under legal notes.—ED.)

Upon the receipt of the official papers (April 16th), the Mayor issued an order to the Commissioner of Public Works, directing the removal of all wires and poles (excepting those upon the elevated structures) on Sixth avenue, from 23d street to 58th streets; on Broadway, from 14th street to 45th street; on 25th street, between Sixth avenue and Broadway; on 42d street, from Sixth avenue to Madison avenue. The several electrical companies received notice of this order and they were asked to shut off all current from the wires, but this was not done, and when the wires were cut by the Mayor's men, the sparks flew in some cases, and caused consternation among the crowds who were witnessing the work. The removal of the poles and wires is still going on, several streets being left in darkness, and many private consumers have been cut off. One death has so far been caused by falling poles, and many narrow escapes are reported, the employés of the city not being experienced linemen. As fast as poles and wires are taken down, they are removed to the city storehouse, the owners not being allowed possession.

The bids for electric lighting for the city were recently handed in as follows:—

The Brush company, 441 lights at 35 cents each a night outside of the subway district, and 65 cents where the subways are to be used; the East River company, 421 lights at 35 cents, and 68 cents in the subway districts; the United States company, 429 lights at 35 cents; the Harlem company, 89 lights at from 35 to 60 cents each; the North New York company, 28 lights at from 35 to 60 cents; the Mount Morris company, 878 lights at from 28 to 55 cents. The last-named company now furnishes only 18 lights, at the rate of 32 cents. Its bid is in competition with the United States, the Brush, the East River and the Harlem companies.

The Callender Insulating and Waterproofing Co., of 18 Cortlandt street, and Newark, N. J., has gone into the hands of the courts, Mr. J. R. Burdick being appointed receiver. Mr. George Callender, the secretary of the company, states that, for various reasons it was decided to wind up the affairs of the old company, so that a new corporation could be formed upon a basis more satisfactory for the handling of business; but on the other hand it is alleged that the competition in their line has been so great that business has been carried on at a loss for some time past.

NEW YORK, April 22, 1889.

PHILADELPHIA.

A New Edison Enterprise Excites the Curiosity of Berks County.—Telephone Legislation in Delaware.—The Philadelphia Electric Light Trust and the Edison Consolidation.—Councils Considering a Peremptory Removal of Overhead Wires.—New Street Lights.—The Franchise of the Frankford Electric Light Co.—New Patents Issued to Philadelphians.

RECENTLY the New Jersey and Pennsylvania Concentrating Co., in which Mr. Thomas A. Edison, is supposed to be interested, bought a tract of eight acres of iron ore lands near Bechtelsville, Berks county. O. S. Hussey, the superintendent of the company, erected a shed on the ground and stored within it all the plans for the additional buildings which are soon to be constructed. It is said to be the intention of the company upon the completion of its plant to experiment with a new electrical process for reducing ore. All the agents of the company have been very guarded about their statements, and such a strict watch was placed upon the premises that a deep veil of mystery has surrounded the entire proceedings. The strain proved to be too great for the curiosity of the residents of Berks county, and when the superintendent visited the shed recently he found that some one had broken into it and abstracted all the diagrams relating to the buildings. The thief evidently thought he was getting the key to one of Edison's most valuable discoveries.

An act has been introduced in the Delaware legislature at Dover, providing that every telephone company doing business within the state shall pay to the state treasurer for the use of the state the sum of $20,000. In case any telephone company doing business in the state shall fail or neglect to pay to the state treasurer the tax imposed for a period of 30 days after the same shall have become due, henceforth it shall be unlawful for such company so failing to pay to carry on its business within this state, and upon such failure or neglect to pay for the period aforesaid it shall be the duty of the state treasurer to issue a proclamation announcing failure or neglect, and if the company undertakes to do business after such proclamation it shall be fined $500 for each piece of business done.

In regard to the rumor that the Electric Light Trust is about to collapse because the Edison Electric Light Co. refuses to join the pool, Professor Marks, the supervising engineer of the Edison Electric Light Co., said: "I know it to be a fact that Henry Villard has secured for the German capitalists, whom he represents, absolute control of all the rights of the Edison Electric Light Co. in the United States. What use he will make of his power I do not know, but if he wants the trust to succeed he has the ability to accomplish his purpose."

A resolution to order the telegraph, electric light and telephone companies to remove all wires from overhead in the built up portion of the city, by October 1, 1889, was taken up by Councils Law Committee a few days ago. The general sentiment was that prompt action should be taken, but the matter was not disposed of.

The new electric lights along Diamond street west of Broad to the park has just been lighted for the first time. Each lamp is swung over the street on an arm projecting 15 feet outside the curbstone, so that the middle of the street will be much better illuminated than by the old plan of locating the lights directly over the sidewalk.

Councils Electrical Committee recently considered the ordinances granting privileges to the Frankford Electric Light Co. The main objection to the bill was that the provision for securing the city the five per cent. contribution on the company's profits was not sufficiently clear. The bill was amended on this point and reported back with a favorable recommendation.

The following list of patents were issued to citizens of Philadelphia during the week ending March 26, 1889:—

William C. Cranmer and S. W. Arnold, constructing underground conduits.

Stanley C. C. Currie, Philadelphia, Pa., assignor to United Electric Improvement Co., Gloucester, N. J., electric distribution by storage batteries.

Isidor Kitsee, Cincinnati, Ohio, assignor to M. Sulzberger, trustee, Philadelphia, Pa. voltaic battery (three patents).

Isidor Kitsee, Cincinnati, Ohio, assignor to M. Sulzberger, Philadelphia, Pa., secondary battery.

Rudolph M. Hunter, secondary battery.

PHILADELPHIA, April 18, 1889.

BOSTON.

Continued Interest in the Electric Railways.—The Overhead Wire Question Still Agitated.—Hearing before the Aldermen on the Petition of the West End Street Railway Co. for a General Overhead Conductor Privilege.—Affairs of the Telephone Companies Discussed at the State House.—The Elevated Electric Railway Scheme Again Before the Legislature.—Electric Light and Railway Notes.—Annual Meeting of the New England Electric Exchange.—The Collection of Patents in the Boston Public Library. Municipal Lighting.

THE electric railway is the agitating feature of electrical legislation at present. At the State House the Committee on Mercantile Affairs have under consideration a bill for placing electric wires underground, which brings in railway overhead and conduit wires, and several orders relating to telephone matters. The Committee on Manufactures have under consideration orders relative to giving gas commissioners powers in electric light matters. The Committee on Street Railways have before them elevated railway projects, operated by electricity, etc. The Boston aldermen are dealing with similar questions, and between them much interesting information is being brought out. The telephone people are the principal sufferers from the electric railway wires; telephone lines in the vicinity of the roads are seriously disturbed; there is such a noise from induction, the subscribers are pouring in complaints to the New England Telephone Co. every day.

Replying to a request for an opinion as to whether or not the board of aldermen has the power to grant to the West End Railway Co. the right to locate electric overhead wires for the running of its cars, and under what statute, if any, said power is given, Corporation Counsel Richardson has stated that if such power is conferred it is under section 5, chaper 31 of the acts of 1799; section 39, chapter 118, and section 4, chapter 413 of the acts of 1887.

The board of railroad commissioners in October, 1888, gave its permission to the West End Railroad Co. to make underground and surface alterations in certain streets named for the purpose expressly stated of establishing and maintaining its overhead electric system of motive power in said streets with poles and wires. It is a fair inference that it was the opinion of the railroad commissioners that the location, by their order, of electric overhead wires for the transmission of power for the purpose of running the cars of the company in the streets named in Boston was lawful.

The corporation counsel is of the opinion that the board of aldermen has the power to grant the right to locate electric overhead wires for the transmission of power for the purpose of running its cars in the streets named in its order therefor.

The matter has been referred to the committee of the whole board of aldermen.

The board of aldermen, as a committee of the whole, gave a hearing at City Hall at a recent meeting on a petition of the West End Street Railway for leave to establish an overhead electric system in streets where tracks are located.

Mr. Henry D. Hyde opened the case for the petitioners, saying that since the West End Street Railway took possession of the street railways, two years ago, it has endeavored to do everything possible to facilitate transportation, and now the managers believe that the overhead electric system is the best one for accommodating the public. He presented a memorial bearing more than 26,000 names in support of the petition.

Mr. Henry M. Whitney, president of the West End company, said that the West End company has honestly and fairly tried the conduit system, and finds its unsatisfactory. The people of Brookline, Brighton and Cambridge would never consent to give up electric cars and go back to horses. The danger of interference of the wires in case of fire has been exaggerated. It is useless to try to run two systems at once. There is no advantage in using electric cars while horse cars are run over the same tracks. What is good for one section is good for another, and the public would be benefited by introducing the overhead system throughout the city.

Ex-Mayor O'Brien said that if the petition is granted the problem of rapid transportation will be solved.

R. H. Stearns spoke in favor of the petition. In reply to a question from alderman Smith, he said he should have no objection to the company's placing a post in front of his store door.

Remarks in support of the petition and the need of a system of rapid transportation were made by ex-alderman Paul H. Kendricken, Hon. Halsey J. Boardman, Hon. R. Worthington, Hon. Liverus Hull, ex-alderman Charles H. Allen, Judge Baldwin, of Allston; John C. Paige, and William T. Van Nostrand.

On the 10th of April the aldermen, sitting as a committee of the whole, continued the hearing.

Mr. Moody Merrill said the people of Roxbury need more cars and a better system of transportation. He thought the overhead electric system would give relief, and he did not think an elevated railroad could be built and made ready for operation for several years. He thought there was less danger from the overhead system than from a conduit.

Mr. Isaac Farnham, an electrician, explained a model showing the operation of the double-trolley system. (Mr. Farnham has invented a most ingenious device to maintain a path for the trolleys at points where tracks intersect.)

Fire Commissioner Fitch said that the fire commissioners desire to protest most emphatically against the most sweeping invasion of the rights of the department and the interests of the city that has yet been attempted. He said that the firemen are brave, but it is not right to subject them to unnecessary dangers, and if the electric current of the railway system can throw down a ton of horseflesh—as it did yesterday—it is difficult to estimate the danger to the public. Even if there were no electric current, the wires would still be a source of great danger, for in narrow streets it would be impossible to raise the aerial ladder and other long ladders. Even if the railway had many men to cut wires, there would still be great danger, but the loss of a few minutes' time means in many instances, greatly increased loss of property and possibly loss of life. He believed that the fire department, from the commissioners down to privates, are earnestly opposed to the introduction of an overhead electric system by the West End Street Railway. There are already too many overhead wires in Boston, and none of them are placed where they ought to be.

Fire Commissioner Tobin said that the danger of erecting an overhead system of wires is immeasurable. In case of fire the wires would delay the raising of ladders, and in many instances would prevent the saving of life.

Mr. H. V. Hayes, an electrician, in charge of the mechanical department of the American Bell Telephone Co., spoke of the double-trolley system, and said that, although he had formerly considered it a physical impossibility, he has by investigation become convinced that it is the best system yet invented.

At the State House, on the 22d ult., the Committee on Mercantile Affairs had before it several orders relating to the telephone business. Representative Fottler, of Boston, presented a bill holding electric companies responsible for all damages caused by electric wires to buildings on which they may be placed. Hon. George A. Bruce, counsel for the Bell Telephone Co., questioned Mr. Fottler and criticised the bill. E. W. Burdett also criticised the measure as tending to make the electric companies do the business of insurance companies. He objected that so much of the bill was out of the scope of the order. It was an act of confiscation. Hon. P. A. Collin was also present and opposed the bill. Mr. Burdett gave figures from the last report of the Boston fire marshal to show that there is much unfounded apprehension as to the dangers from electric wires. Only seven-tenths of one per cent. of the fires were caused by such wires. There is great danger to electrical science and business from ill-founded popular apprehension. To Mr. McEnaney Mr. Burdett said that the idea that electric wires should be put underground was the worst error of all. Mr. Bruce said that there is great caution in attaching wires to buildings and that they are not attached without the consent of the owner. Mr. Fottler said he introduced the order from the private complaint of a large property holder in Boston.

After this, the committee took up the orders in regard to compelling telephone companies to furnish free service to cities and towns, and in regard to reducing telephone rates. Mr. Mellen, of Worcester, said that telephone companies should be required to make more detailed returns. He would have them put under such regulations as railroad corporations and savings banks. The Bell Telephone company asks for $10,000,000 capital, and it ought to give reduced service in return for what it gets. He had some interesting facts to lay before the committee regarding the relations of the company to the public. He moved that the matter be postponed and considered in connection with the Bell company's petition, and until he could collect further information. The public ought to have a fair show against this great company and ought to have all the statistics obtainable. Mr. McEnaney, of Boston, moved that the consideration of the two orders be postponed till the hearing on the increased capitalization of the Bell company. Mr. Bruce said that the telephone business of the state is conducted by the New England Telephone and the Southeastern Telephone companies. A bill to regulate rates would affect these companies and would affect the Bell company only indirectly as a holder of their stock. Those companies should not be mixed up with a hearing for the increase of the Bell's capital stock. The matter was discussed at length, and the hearing on the two orders was postponed to a date not fixed.

The Committee on Street Railways recently continued the hearing upon the petition of F. M. Ames and others for incorporation as the Boston Electric Elevated Railway Co. Warren S. Hill, an expert in electrical science, considered the New York elevated system as near perfection as had yet been reached. Mr. Hill thought the element of danger from electric wires would be lessened by having them carried upon supports such as were possible upon an elevated railway. Nathaniel J. Rust, one of the intending co-operators under the Ames petition, spoke of the necessity and advantages which would come from elevated rail-

ways, and declared that he had signed the petition in good faith and with full intent to act under a charter, should it be granted.

James F. Almy, of Salem, and Mayor Titcomb, of Newburyport, said that they had entered into this enterprise in good faith, and were ready to subscribe if a charter is granted. The hearing was adjourned.

On the 2d of April the Waltham city government gave a hearing to the Newton Street Railway Co. on its petition to operate an electric railway by the Thomson-Houston single overhead trolley system. It is proposed to run cars by electricity on a circuit from Waltham, West Newton, Newton and Watertown. Mr. Powers, on behalf of the New England Telephone Co., suggested that the double-trolley system be used. The representatives of the railway company answered that it is utterly impossible to use such a system on the proposed railway.

The Naumkeag Street Railway Co, of Salem, hopes to get electric cars running on its main Peabody system by July 4.

At Woonsocket, R. I., the board of aldermen has decided to grant its local street railway company a franchise to substitute electricity for horse-power. Woonsocket introduced the first electric cars run in New England, in 1887, but the service was not entirely satisfactory and a franchise was denied and the service discontinued after a three months' experiment. With the improved overhead system the aldermen are now willing to grant a full franchise, and the entire system will be equipped as soon as practicable.

The New England Electric Exchange held its annual meeting on the 8th of April at the rooms of the Boston Electric Club, 7 Park street, president P. H. Alexander in the chair. The following-named officers were elected: president, P. H. Alexander; secretary, H. B. Cram. These officers, together with Frank Ridlon, A. Robinson, and Y. Bradbury, constitute the board of directors. President Alexander, in his address, referred to the pleasant relations existing between the exchange and the insurance men. He stated that there had been for the year 175 applications for licenses; 150 had been examined, and of these 144 were granted certificates. Sixty-eight obtained a lower grade and four a higher grade than examined for, and six were rejected as totally unfit for the business of an electrician. In addition to the regular business there was a discussion of the "Insurance Requirements for Electric Lighting Stations," growing out of the fact that there had been considerable trouble of late in obtaining insurance on central stations. A paper was read by M. J. Perry, of Providence, upon "Economical Steam Plants for Electric Lighting Stations."

The new room of the patent collection in the Boston Public Library has been now opened. The old room having become overcrowded, it was found necessary to occupy the art room on the ground floor. The collection includes American, English French, German, Belgian, Australian and Canadian patents—in all 4,000 volumes.

The electric lighting of cities has become a question of much importance to their inhabitants. Investigations have recently been made as to the expense of lighting the streets of various cities by electricity, and it has been ascertained that Boston pays 65 cents each night per lamp, Lowell 55, Worcester 55, Springfield 60, Bridgeport 50, Hartford 54, Fall River 56, New Bedford 50, Providence 50, New Haven 50, New York 40, Albany 50, Newark 50, Philadelphia 47, Baltimore 50, Washington 65, San Francisco 66. Of these cities it will be noticed that Boston stands near the head of those paying the most for its electric lighting. In the cases above cited the work is performed by private companies. But there are towns which have their own electric plant, and to them the cost of such lighting is apparently insignificant. In Chicago it does not exceed 15 cents per lamp each night. In Portsmouth it costs 10 cents; Decatur, Ill., 13.7; Michigan City, 12; Topeka, 20; Lewiston, Me., 20. These figures may look alluring, and they undoubtedly do show that Boston has been paying too much for its electric lights. But they are by no means conclusive. Politics enter largely into municipal undertakings, and the figures given as to the cost of working city plants may safely be taken with much reservation.

BOSTON, April 16, 1889.

CHICAGO.

The Chicago Electric Club Secures More Commodious Rooms; its Meeting of April 15.—The Telephone Bill Hung Up in the Illinois Legislature.—The Central Union Telephone Company's Cogent Presentation of its Position.—Pennock in Chicago with his Primary Battery Scheme.—The Western Union Telegraph Company Sued for $10,000 Worth of Peace of Mind.—Death of Mr. Edward P. Allis; his aims for Industrial Reform.—Personal Mention.—The New York Conduit Explosions Discussed.—A Company with a Title Too Full for Utterance.—Electric Lighting in Japan.—Electric Light Contracts.

THE Chicago Electric Club, after a year or more of discussion, has finally decided to move into new quarters. It has been stated a number of times in the Chicago letter that the club was dissatisfied with its present quarters, and looked with envious eyes at the more fortunate organizations in New York and Boston. It seemed necessary in order to make the club meet the requirements of the members that its quarters should be located in a central part of the city. A search for rooms has been in progress for a year, but until within a few weeks nothing suitable could be found. It has now been determined to rent two floors in the High building on Adams street, which adjoins Kinsley's restaurant. A door will connect the club rooms with the restaurant, so that the members will enjoy the advantages of an unexceptionable cuisine. It is an arrangement which seems to meet the approval of all the members of the club. Already the membership is beginning to increase with the prospect of new quarters. It is expected that within a short time the members will number at least 200. The club rooms are to be elegantly furnished, and electric lights will be used throughout. It has been rather humiliating to Chicago electricians to sit in quarters lighted by smoky, flickering gas jets. At the meeting April 15th Fred De Land read a paper in which he reviewed at length the history of the club. The club has done considerable effective work under extremely unfavorable circumstances during the last two years.

The Eckhardt-Baker Telephone bill, the provisions of which have already been given in the correspondence from Chicago, remains in about the same shape in the Illinois Legislature. The chances are thought to be against its passage—a fact which is extremely gratifying to the Chicago Telephone Co. An attempt was made in the early part of the month to advance the bill, but as the requisite two-thirds vote could not be secured, the effort fell through. Those who had failed to force the bill ahead made charges accusing those who had disagreed with them with corruption, and a lively scene followed in the House. Members used language which scarcely reflected credit upon the body. It was also suggested that newspaper representatives who charged members with corruption should be excluded, but no action of this kind was taken.

A second attempt to take up the bill out of its regular order failed.

Senator Eckhardt introduced a bill providing that if the companies refused to operate under the proposed law they should forfeit their franchises.

The Chicago Telephone Co. has sent to the members of the Legislature a statement of its claims. Among other things, it says:—

"The rates now charged in Illinois are lower than those in many other states for facilities furnished. They are based upon the length of line, character of equipment, and facilities required in each case, and this company protests that any other fixed basis for rates at present would be impracticable, and could not fail to destroy this useful industry, or greatly retard its development. The average rate paid by exchange patrons of the Central Union Telephone Co. (which operates most of the exchanges and lines throughout the interior of this state) is about $3.49 per month, but this average rate would fall far short of covering the actual expense of furnishing telephone service in larger cities, like Chicago. The rates proposed by this bill are but a small reduction to each subscriber, but to the Central Union Telephone Co. this reduction is a great matter, involving the difference between moderate returns upon an investment and the impossibility of continuing the business at the prices named in this bill. The difference between existing business and residence rates is due to the fact that business subscribers use the telephone more than residence subscribers, and get more benefit from it at an increased cost to the telephone company for furnishing the service. The practical result of the bill would be to give business men, who use the facilities most, who receive the greatest benefit, and whose service entails a greater expense upon the telephone company, the same rate as the residence subscriber, who receives but comparatively little service and corresponding benefit. It would, in fact, be taxing the housekeeper for the benefit of the business man, by making the housekeeper pay a portion of the expense of the business man's service."

Can primary batteries supply current for incandescent lamps more economically and more efficiently than dynamos? George B. Pennock, of a primary battery company of Chicago, which bears his name, answers this query in the affirmative. The Chicago *Tribune* recently devoted considerable attention to the subject, and insinuated a negative answer, and stated that Mr. Pennock's great object was not to make installations of his system, but to dispose of stock in his company at $1 a share. Of course Mr. Pennock made an emphatic denial, in which he took occasion to state that the generation of electricity by dynamos was a complete failure, and that his system gave the only effective and economical incandescent lamps.

Professor Badt then took a hand in the controversy. He published a communication in which he proceeded to characterize Mr. Pennock's system in terms that will not tend to increase confidence in the inventor's good faith.

Mrs. Hannah Joseph has commenced a suit against the Western Union Telegraph Co. to obtain $10,000 damages. The amount she asks is to compensate her for a night of suspense and worry. Her husband telegraphed her that he was not coming

home one Saturday evening. The message was not delivered, and her worry about her husband's safety, she alleges, seriously impaired her health.

E. P. Allis, of Milwaukee, known to electric light men throughout the country, died April 1st. He was proprietor of the Reliance Iron Works of Milwaukee. Mr. Allis's property was estimated at several millions. This interesting paragraph appeared in his will: "It has long been a cherished idea of mine to convert these works into some sort of a co-operative or profit-sharing institution, but the proper method and time have never been clear for me to do so with a surety of success. I believe such an arrangement is the proper one for all concerned in its management and operation, and that it will soon be feasible, and I commend its careful investigation and, at the proper time, its adoption by my trustees." No public bequests are made, and in explanation of this the testator says: "In this will I have made no outside bequests, deeming the size of my family and the central idea of a great and publicly beneficial Milwaukee industrial institution with ample means and the family name as precluding and taking the place of any other bequests."

F. N. Armour, who has represented the C. & C. Motor Co. in Chicago, has been appointed agent for isolated plants for the Edison company. A. H. Lewis will hereafter represent the C. & C. company.

Chicago electricians have been considering with interest the question of explosions in the New York subways. In view of their experience with Chicago conduits their opinions have been solicited. The general belief seems to be that the explosions are caused by spontaneous combustion, though in the case of the explosions in the Edison man-holes the spark was traced to the wires. The Edison company proposes as a remedy to put uncorked bottles of chloroform in the man-holes.

A company bearing the following formidable title was incorporated recently: United States Vogel-Kazophone-and-Electrical-Micophone-Trumpet-Acoustic-Electromotor-Power-Musical-Far-Distance-Loud-Speaking-Transfer-Instrument Company of Chicago. The incorporators are William Vogel, Adolph Gray and Richard H. Dakin. The capital stock of the company is $60,000,000. What the company proposes to do can only be conjectured. The organizers of the many-worded corporation refuse to disclose in any way what their instrument is or what their intentions are.

The Western department of the Excelsior Electric Co. has secured the contract for furnishing the arc light plant for St. Joseph, Mo.

Lieutenant Yoshie, one of the staff of a Japanese Prince who is visiting America, was recently interviewed in Chicago concerning the extension of electric lighting in Japan. He said the lights were extremely popular. He made one point which will interest the writer of the next paper on electric light and fire risks. He said while incandescent lights were more expensive than other illuminants, still the increased cost was not considered an objection, as the difference in the prices was looked upon as a premium paid for a sort of insurance.

Frederick Sargent, the general superintendent of the Chicago Edison company, has resigned to accept the position of chief mechanical engineer and superintendent of construction of the Edison United Manufacturing Co. of New York. Mr. Sargent's friends have given several dinners in his honor, and presented him substantial tokens of their esteem.

George Cutter, a well-known electrical engineer who has been connected with the Thomson-Houston company, of Chicago, has resigned his position and has started a business of his own. He will handle specialties, and will engage to a limited extent in the supply business.

The contract for lighting Springfield, Ills., has been awarded to A. L. Ide, of the Ide Engine Co. A company to perform the work has been incorporated by A. L. Ide, G. N. Black and S. D. Shales. The capital stock is $100,000.

CHICAGO, April 12, 1889.

MONTREAL.

Wiggins's Predictions.—The Canadian Underground Wire Bill Rejected by Parliament.—The Litigation of the Telegraph Companies.—Lachine to have Electric Lights and Fire Alarm.—Mr. Frank Redpath's Private Lighting Plant.—A Gibson Storage Battery in the Bank of Montreal.—Personal Notes, Including Mr. Brown.—Electric Light Notes.—A Westinghouse Plant at Hamilton.—New Edison Contracts.

READERS of the ELECTRICAL ENGINEER, doubtless have all heard of Wiggins! the irrepressible Wiggins! He promised us for the early spring, the most severe cyclonic storm ever experienced. The cyclone has not as yet kept its engagement. This, however, does not prevent Wiggins's further predictions. His latest fad, is that the telephone and telegraph wires and wire fences have an evil influence on the course of storms, centering the storms where the wires are thickest. That is not all; the influence the wires have, has caused a cessation of the northern lights. Wiggins may deprive us of our cyclones, and give them to our more favored neighbors, but the northern lights—we must have our northern lights at any cost.

The Underground bill, mentioned in last month's letter, has been presented before Parliament, and was reported on adversely, and thrown out, on the ground of provincial rights previously conferred. The Toronto City Council have in accordance with the views thus expressed by parliament, enacted a by-law putting the control of all telegraph, telephone and other wires under control of the Common Council.

The suit of the Great Northwest Telegraph Co. *vs.* the Montreal Telegraph Co. is in progress. No decision being as yet reached, it seems probable that the holders of Montreal Telegraph Co.'s stock will be forced to accept a lower rate of interest, for in case they refuse to do so, the Great Northwest company can forfeit their lease, thus leaving the Montreal company without a connecting line to the states; they will thus be forced to divide the small business now being done, between three companies instead of two as now.

The citizens of Lachine, a suburb, and summer resort for Montreal people, are desirous of having modern improvements, and are preparing to put in a fire alarm and electric light system.

Mr. Frank Redpath, of Montreal, an enthusiastic electrician, has been for some time lighting his house by electricity, driving the dynamo by means of a gas engine. He has recently added a Gibson storage battery outfit.

The Bank of Montreal has also been supplied with a system of Gibson batteries by Mr. Lawson, who was formerly with the Edison company, but now located at Montreal, in a general electrical business.

Mr. W. R. Kimball, formerly with the Royal Electric Co., has severed his connection there, and is now doing a general electrical business, with head-quarters in Montreal.

Mr. Brown, of "death dealing current" fame, has recently been in Montreal, on a mission of benevolence, enlightening the citizens as to the dangers lurking in the electric light wires, and especially in the alternating current wires, put up under the supervision of the city electrician and insurance inspector. The Montreal public will hardly realize how self-sacrificing Mr. Brown is, to have gone so far from New York on his disinterested mission. It is an open secret, known here I believe, to some, as it is generally in New York, that Mr. Brown goes on his missions of love for nothing else than the good of mankind, and in so doing feels amply remunerated.

The Royal company report the sale of a 100-light incandescent plant for Norris's mill at St. Catherine's, 30 arcs and 500 incandescents (alternating) for a central station at St. Johns, P. Q., also 1,000 lights alternating at Quebec, P. Q.

The East End station, a part of the 600 arc lights' increase in the city lighting, is well under way. The motive power will consist of two pairs of 16 x 36 Brown engines of a total capacity of 600 h. p. The addition to the main station will consist of a pair of 18 x 42 Brown engines of 500 h. p. capacity. The 600 lights are to be ready first of July.

The Westinghouse company are putting in a 500-light alternating plant at Hamilton, Ont.

The Edison company report the sale of central stations as follows:—

Brandon, Man., 480 lights, Pembroke, Ont., 640 lights, Woodstock, N. B., 320 lights, Chatham, N. B., 320 lights, and to the Ogilvie Milling Co., Winnipeg, 160 lamps, Canadian Pacific Railway steamer *Manitoba*, 240 lights. Increase in steamers *Alberta* and *Athabaska*, 57 lights each, Albert Weiner, Copelton, Quebec, 160 lights, Copelton, Quebec, Chemical Works, 120 lights, increase Potter Mfg. Co., Sherbrooke, Quebec, 80 lights.

MONTREAL, April 22, 1889.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall street, New York city.*

ELECTRICAL COURSES IN COLLEGES.

[105.]—In answer to a communication in your March number would say, that evidently Mr. D. C. Jackson has not fully looked up the matter of electrical engineering departments at certain technical colleges, at least not Cornell University, or if he has, he surely has made a mistake and given wrong impressions in his communication. It is a known fact that certain *practical* electricians, as they call themselves, are continually harping about

the worthlessness of the course of instruction given in electrical engineering at technical colleges, and give everyone the idea that the students only obtain a theoretical knowledge of electricity and have only a vague idea of anything that is practical in the electrical world. A more erroneous impression could not be had. It was not the "*fashion*," but because of the *necessity*, that courses of this character were founded in the technical colleges.

Mr. Jackson says that: "the course in electrical engineering" at these colleges, "is tacked to the department of mechanical engineering or of physics, and in consequence either does not receive due attention or active practical treatment."

Such is hardly the case, for a more practical course is not to be found at Cornell University than that of electrical engineering. Having a full corps of practical electricians to give instructions and an equipment containing dynamos, lamps, motors, etc., of nearly all known systems; several complete outfits of which are in actual operation. A very large field of practical work is open to the students in this course. A part of the junior and the entire senior year is devoted to practical electrical work.

The reason the electrical engineering course is generally taken in connection with the mechanical engineering course for the first two years is because the preparation is similar for both. To be a good electrician one must have a thorough knowledge of higher mathematics, physics and mechanics, and, in fact, all that make up a good mechanical engineer. For this instruction why should he not have similar training to that of the mechanical engineer? It is true, he should be a specialist—" an *electrical* engineer"—and he obtains this specialist's study at the technical college in the last two years.

This field of work is new, and it takes time to perfect the course of instruction; but even at the present day the technical colleges are doing more to turn out useful practical electricians—men having higher aims than to be dynamo tenders or line men —than could be done in any other way. If, instead of finding fault with what is being done, such able electrical engineers as Mr. Jackson would show a greater interest in making the course of training what it ought to be, all would be benefited thereby.

FRANK C. PERKINS.

Cornell University, Ithaca, N. Y.

ELECTRIC LIGHT CONSOLIDATION IN AUSTRALIA.

[106.]—I believe that your columns are open to any appeal for truth and justice, more especially in the interests of electric lighting, and for that reason I ask you to publish a protest against the terms of an article appearing lately in the columns of the English *Electrical Review* for February 1, page 129, on the subject of the Australasian Electric Light, Power & Storage Co., Limited.

It certainly seems a pity that the writer of that article should not have taken the trouble to inform himself somewhat more accurately before he set forth in black and white statements which are undoubtedly prejudicial to the interests of the shareholders in a deserving industry and of benefit to no one, being inherently rash and fallacious. He states, for instance, that the Australian Electric Co. was wound up some months ago, and that the assets represented formerly by the 18,000 shares in that company, had ceased to exist. This statement is untrue. The Australian Electric Co. is not yet actually wound up. A new company with more extended powers and increased capital has been registered with the object of purchasing and taking over the business which will consist, practically, of the same shareholders and will be the same company under another name and with more extended powers. The position of this little company is better, stronger and more full of promise than it ever has been yet.

Again, the writer of the article in question would imply that the directors are speaking without warrant when they talk confidently about the central lighting station. Some 2,500 16 to 20-c. p. lamps equivalent to over 3,000 10-c. p. lamps, such as are ordinarily used in the best lighting stations in England, are now being rented from the company at full prices. Fresh customers are being secured almost weekly, and it will not be long before the full capacity of the lighting station will be reached. This may be taken at about 6,000 Swan-Edison 40-watt lamps. The actual value of the land, buildings and plant may be put down at about £20,000, with a capacity for yielding a net revenue of over £4,000 per annum in well established contracts, many of them of several years duration. To ask for £40,000 in shares, not in cash, in a new company for such a business as this connected with some of the best business men and firms in the colonies, is surely not an excessive demand.

Another statement made by the writer in the *Electrical Review*, who seems quite independent of all authority for what he says, is that the Electric Light and Power Supply Co., of Australia, will not amalgamate, but intends to fight. Now, this is so far from being the policy of the company in question that the directors on both sides are personally on extremely friendly terms, and the Electric Light & Power Supply Co. has already commenced the policy of amalgamation by joining in the formation of a new company called the "Union Electric Co.," and the directors of both companies forming the union have openly stated their desire at an early period, to further amalgamate with the new Australian Electric Co., Limited, and its friends, quite irrespective of the particular system or systems to be employed. They consider that this latter point should be determined solely by the merits in point of output, workmanship and economy of the different systems which are now available. Such a combination as is here suggested, would be as strong, probably, as any that has yet been brought about in electric lighting. Does it not then seem rather hard that a scientific paper of the character of the *Electrical Review*, should give its sanction and tacit approval to such an article as the one alluded to, in which the writer most unjustifiably makes statements which are not only untrue in themselves, but which he could have corrected with the information at his disposal in London at the time he wrote them.

Trusting that you will oblige the Australian Electric Co. by the insertion of the foregoing.

I remain, Sir,

Yours faithfully,

F. C. ROWAN,

General Manager in Australia of the A. E. L. P. & S. Co., Limited, and late Managing Director Australian Electric Co., Limited.

Melbourne, March 15, 1889.

LITERATURE.

Economic Value of Electric Light and Power. By A. R. FOOTE, Cincinnati: Robert Clarke & Co., 1889.

THIS book is addressed to investors, the managers of industries, students of industrial methods, and to municipal authorities rather than to electricians. Mr. Foote is far from claiming expert knowledge of electricity or of its application to the purposes of light and power. He is a student of industrial economics, and in the volume under notice directs his attention and the reader's to the economic aspect of the part which electricity is to fulfill as a means of distributing and utilizing energy for the production of light and power.

His argument is two-fold. First, that electricity will at no distant day supersede all other means for transmitting power over municipal areas; and, second, that the development and use of electrical distribution, whether for private or public service, should be left to the untrammeled employment of individual or associated capital and enterprise; that is, free from state or municipal competition or control.

Electricity is to be "on tap," as one might say, throughout all cities and towns for light in all streets and houses, and power for all machines; but the full economic benefit of this common supply of energy can be secured to the whole community only by the absence of all state or municipal ownership or management in providing it.

It is gratifying to electrical engineers, and to the owners and managers of electric lighting and power plants, to find both these positions maintained by a writer who looks at the whole subject from an outside point of view. Probably, however, there are not a few readers of the first-named class who may feel disposed to modify some of Mr. Foote's unqualified expressions of confidence in the capability of the electrical engineering art of to-day to vanquish all problems of distribution.

While witnessing the remarkable advance in methods of long-distance supply that has been achieved during the last five years, and the daring undertakings based upon them now in progress, it can scarcely be doubted that electricity will ultimately become the chief means of illumination and of the distribution of power; but the electrical engineer may still feel inclined to withold his assent from Mr. Foote's confident assertion that "the demonstration is now complete that all the illuminating and power service of a city can be performed from one central station." We assume, of course, that he means any city, or large cities, and we venture to think it would be well to await the results of operating some plants now constructing, notably the huge Deptford station for supplying a large section of London, before announcing a "demonstration." The economic value of concentration, *i. e.*, the superior economy of wholesale over retail, is undeniable, but, while we have no notion of recording an opinion against the ultimate employment of the single station plan of distribution in large cities, it should be borne in mind that sufficient experience in very wide distribution on a large scale has not yet been accumulated to warrant unqualified confidence in its superiority to a district system.

Whatever electrical engineers may think of the author's views upon the proper relation of municipal governments to the business of general electric supply, few, if any, dissenting voices will be found among the owners of central station lighting and power plants now in operation, except, perhaps, as to his second proposition on the subject, to wit: that a municipality should grant the privilege or franchise to but one company. All will agree in commending the suggestion that no city or town should

own and operate a light and power plant, but when it comes to shutting off or out all companies but one, the question very likely to arise in many cities now supplied by several companies would be, which shall be "in" and which "out"? Mr. Foote would not only confine the service of a city to one company but would "eliminate from the grant all needless restrictions." The word "needless" gives much elasticity to the phrase, and it may fairly be inferred that the author would not regard as needless some control of service charges on the part of a municipality granting a monopoly of electric lighting and power supply. It would seem, moreover, that some degree of supervision or regulation of line construction ought to be secured to municipal authorities. "Electrical law and order," to use the happy phrase of Dr. Schuyler Wheeler, is imperative in future construction of lines, whether overhead or underground; and we fear the golden age has not yet fully arrived, when enlightened self-interest alone will prevent the further employment of inadequate and disorderly, that is, cheap, methods by some of the exploiters and promoters of electrical enterprises.

Mr. Foote has included in his volume his paper on "Municipal Ownership of Commercial Monopolies," read before the National Electric Light Association, at Chicago, in February, where it attracted well deserved attention. He has also reprinted a number of articles and papers by various hands and extracts from electrical journals bearing upon several aspects of electrical industries related to the theme of the book. In its general drift the volume is, we think, in harmony with the views of professional electricians as to the scope and power of their art to deal with light and power, and consonant with the most enlightened opinion in respect to the relations of municipal governments to industrial enterprises. It is perhaps to be regretted that the author has chosen to present his views in so sententious and aphoristic a style, a method of writing ill suited to elucidation or argument on so practical a theme as the economic aspect of electric light and power. Few will dispute Mr. Foote's numerous maxims, but they bristle on every page, and detract from the sobriety befitting the subject of the book.

Notes.

Turning Lathes: A Manual for Technical Schools and Apprentices. A Guide to Turning, Screw-Cutting, Metal Spinning, etc., edited by James Lukin, B. A., is a small volume that ought to find its way into the hands of young amateur workmen as well as of the students and apprentices referred to in its title. The work is clearly meant for beginners, and is extremely elementary, so much so indeed, that most apprentices might at first be inclined to resent being told what a mandrel or a headstock or a chuck is. But let them read on and they will learn much and enjoy the book as well as benefit by the study of it. They will learn fully and accurately some things that they have but partially known or understood, and will find reasons or explanations which they may have failed to receive from their superiors in the workshop. The book is fully illustrated with uncommonly good cuts. The publishers are E. & F. N. Spon, of New York, and the price is $1.50.

Dr. Leonard Paget has in the hands of publishers, a book entitled, "Dynamo Construction," the subject-matter of which has special reference to the construction and operation of alternating current dynamos and motors. He also has in hand, not yet ready for the publishers, however, a book entitled, "Graphic Arithmetic," directed particularly to the solution of electrical problems that are difficult and some times impossible to solve by ordinary arithmetical methods. This work is directed to the graphical solution of such problems.

Berly's Universal Electrical Directory for 1889, Wm. Dawson & Sons, publishers, London, has been materially increased in size. It contains 49 more pages than the edition of 1888. This work has now become familiar in electrical trade circles throughout the world. The especial purpose of the editors and publishers is to produce a trade guide excluding all technical matter, tables, formulæ, etc., and making it of the fullest value to manufacturers, dealers and electrical and mechanical engineers generally, as a purchaser's directory.

CATALOGUES AND PAMPHLETS RECEIVED.

The University of the City of New York. Catalogue and Announcements, 1888-9. The summary of the University instructors and students for the year is as follows:—Arts and Sciences: Professors, 24; Lecturers, 8; Students, 181. Medical School: Professors and Lecturers, 55; Students, 627. Law School: Professors, 3; Lecturers, 8; Students, 107. Totals: Instructors, 98; Students, 915; in all, 1,018.

Steam: Its Generation and Use. Under the foregoing title the Babcock and Wilcox Co. issue a neatly bound and handsomely illustrated octavo volume of 120 pages, containing a full exposition of the principles of operation of their boilers, with detailed and illustrated descriptions of their construction; tests of many of their outfits from the records of the owners of them; and a catalogue of the manufactures of the company. The work of this company has achieved a high standing among engineers and manufacturers; and all who are interested in the purchase or operation of steam plants will find full information of the peculiarities and excellences of their boiler construction in the volume above-mentioned. This latest edition contains much new matter, together with information that has been hitherto found only in detached publications and now brought together conveniently.

The Woodhouse and Rawson Electric Supply Co., of Great Britain, Limited, send us the second edition, revised and enlarged, of their Contractors' Electrical Supplies. The Woodhouse and Rawson company takes nothing less than the world for its field, and judging from the list before us aims to omit no branch of electrical application from the lines of apparatus and supplies which it offers to furnish. The range of the catalogue may be inferred from the statement that it includes dynamos—direct and alternating—motors, arc and incandescent lamps—even steam engines at one extreme—and the most insignificant items of domestic service supplies at the other. Between these limits are included about everything electric known to the practical arts, embracing many specialties of the Woodhouse and Rawson company in the various departments of their manufacture and trade.

We have a pamphlet from the Sperry Electric Co. of Chicago, which courteously salutes the reader with a "Good Morning" in its opening page and takes leave of him with "Good Night" at the foot of the 39th page. The intervening pages, while filled with much interesting matter, setting forth the advantages of Mr. Sperry's system of electric lighting are hardly likely to tax the brain of the reader from dawn to nightfall. Mr. Sperry has achieved some distinction in the field of electric lighting, and in the sheet of illustrations accompanying the circular of the Sperry Co. shows a dynamo of several peculiar and interesting features of design. Very strong claims of superiority over all existing arc-lighting systems are presented in respect to dynamos, regulators, lamps, switches, and every other feature.

The Telegraph Cypher Code and Catalogue of the Page Belting Co., Concord, N. H., comes to us in a new edition for 1889. The pamphlet includes, in addition to a catalogue of rubber and leather belting made by the Page Co., a series of practical rules for the purchase and use of belting, information upon the kinds and grades of belting to use for different kinds of work, and a cypher telegraph code for the use of customers in ordering.

NEWS AND NOTES.

THE WESTON ARMATURE PATENTS.

PATENTS Nos. 401,668 and 401,669, issued April 16th to Mr. Edward Weston, assignor to the United States Electric Lighting Co. (now leased to the Westinghouse Electric Co.), are apparently of very much importance to all makers or users of dynamos and motors or inductive generators, whether primary or secondary. The published announcement of the Westinghouse Electric Co. of its intention to deem as infringers of these patents all who make, sell or use dynamos or motors "provided with sectional armatures built up of iron plates, which are separated by interposed insulating material," probably concerns a very large portion of all the manufacturers of electric lighting and power apparatus in the country.

The matter is of such obviously general interest that we give below some extracts from the specifications of both the Weston patents and the claims entire:—

The drawings of both patents are identical, and show a drum armature in longitudinal section, having a wooden core surrounding its shaft and alternate discs of iron and insulating material upon the core.

The specification of patent No. 401,668 contains the following:—

"My invention relates to dynamo or magneto-electric machines containing cylindrical armature-cores wound longitudinally with conductors, which are caused to move in a magnetic field at right angles to the lines of force.

"The invention consists in a novel and useful construction of said cylindrical cores, whereby the circulation of induced currents is effectually prevented and the process of manufacture facilitated and greatly cheapened. These objects I attain by constructing the cylindrical core partly of magnetic and partly of non-magnetic material, the former being in the form of rings or discs, which are strung over a central hub or cylinder of wood or similar insulating substance, and prevented from contact with one another by interposed rings or sheets of insulating material."

The claim is as follows:—

"In a dynamo-electric machine, the combination, with the shaft, of a cylinder or hub of insulating material secured thereon, iron plates or rings strung over said hub, and plates or sheets of insulating material interposed between said rings, these parts being constructed and combined in substantially the manner set forth for the reception of the coils."

Patent No. 401,669 is broader in scope. From the specification:—

"My invention relates to electrical apparatus in which the coil or coils for the development of electric currents by inductive action is formed by winding an insulated wire or conductor around a core formed of magnetic material.

"Primarily the invention relates to magneto or dynamo-electric generators, or, in other words, to machines in which the magnetic core, wound with an insulated coil, is moved with reference to a magnetic field or the field moved with reference to the core in such manner, in either case, that the lines of magnetic force will be cut by the conductors at right angles, or as nearly so as practicable; but the invention is also applicable to other forms of electrical apparatus in which use is made of a magnetic core wound with an insulated coil or coils in which currents are developed by inductive action, and in which, in other respects, similar electrical conditions obtain to those met with in the ordinary form of dynamo-electric machines. In all such machines where the coils wound on an iron core are subjected to inductive action by their movement with respect to the lines of force, or

conversely, it is obvious that the same inductive action tends to generate currents in the body of the core itself, and this would occur if the core were formed of a solid mass of iron, or if it were so constructed as to present closed paths in the body of the material composing it parallel to the convolutions of the coils. Such development of currents in the core would obviously involve a waste of energy, and it would also operate injuriously by heating the core and coils, so as to render their continued use difficult or impracticable.

"My invention consists in a novel and useful construction of such cores, whereby the injurious results due to the generation of induced currents in the body of the core are avoided, the process of manufacture facilitated and cheapened, the mass of iron in the core more effectively increased, and its magnetic continuity in the direction of the lines of force traversing it more nearly preserved. These objects I attain by constructing or building up the core of alternate sections of magnetic and insulating material, by preference using a number of discs or plates of iron, arranged at right angles to the direction of the coils wound upon the core, with rings, sheets, or plates of insulating material interposed between them.

"Though described in connection with a core cylindrical in its general configuration, it will be readily seen that the invention applies equally to other forms of cores—as, for example, the ring, or annular cores now in use in machines of the Gramme type.

"I do not here claim the combination, in a dynamo-electric machine with the shaft, of a cylinder or hub of wood or other insulating material, iron plates or rings strung over said hub, and plates or sheets of insulating material interposed between said rings, inasmuch as this feature is the subject-matter of my application for letters patent filed September 22, 1882, Serial No. 72,475, of which my present application is a division."

I am aware that cores have heretofore been made with air-spaces between the several magnetic sections, and also that cores composed of bundled wires have been used, and I do not claim, broadly, herein a sectional or compound core; but

What I claim is—

1. A core for electrical generators operating by inductive action, composed of alternate sections, plates, or discs of magnetic and insulating materials, in combination with insulated coils wound thereon, as set forth.

2. A core for electrical generators operating by inductive action, composed of iron plates, sections, or discs, with interposed plates or sections of insulating material, in combination with insulated coils wound thereon at right angles to the planes or lines of the insulating sections, as set forth.

3. A core for electrical generators operating by inductive action, composed of iron sections, plates, or discs, with interposed plates or sections of insulating material, in combination with means for binding and holding the same together, and insulated coils wound thereon at right angles to the planes or lines of the insulating sections, as set forth.

THE TELEPHONE.

AT the meeting of the newly elected board of directors of the American Bell Telephone Co., Mr. John E. Hudson, who has been general manager since the retirement of Mr. Vail, five years ago, was elected president, succeeding Mr. Howard Stockton, resigned.

IN the Tennessee Legislature, on the 9th of March, a bill was introduced, which proposes to regulate the charges for telephones. The rate fixed in the measure is $36 per annum.

On the same date, in Texas, the clause in the charter of the city of Fort Worth, granting the city authority to regulate telephone charges, was eliminated in its passage through the House of Representatives.

ON the 11th of March, the bill providing a $3 per month rental for all telephones, failed to pass the Arkansas Legislature.

THE Hamilton bill, to regulate telephone charges in New York City, was defeated in the New York Assembly, on the 27th of March.

IN Missouri there have been 18 telephone bills before the present legislature. The rate bill is the only one that has made much progress. It would reduce monthly telephone rentals to $4 and toll charges to 15 cents.

A CASE involving a conflict between electric street railways and telephone companies, in regard to their respective rights to earth and air on city thoroughfares, was decided at Akron, Ohio, last week. Judge E. H. Green refused to grant the Central Union Telephone Co. an injunction restraining the Akron Electric Street Railway Co. from extending its line in the city. The telephone company claimed that induction from the electric railway wires makes it impossible for many of its subscribers to use their instruments.

A HEARING on the petition of the American Bell Telephone Co., for leave to increase its capital stock from $10,000,000 to $20,000,000 was held before the Committee on Mercantile Affairs of the Massachusetts Legislature on April 18. There were present besides Messrs. Bruce and Collins, counsel for the telephone company, Messrs. Forbes and Blake, directors; E. J. Hall Jr., general manager, and Angus S. Hibbard, general superintendent of the American Telephone and Telegraph Co., Stephen M. Weld, Henry L. Higginson and others. No remonstrants appeared.

In the course of the argument for the petitioners it was shown that upon the organization of the company (as the National Bell Telephone Co.) in the year 1877, the capital of $450,000 was deemed ample, but the development of the business necessitated an increase to $850,000 in 1879, and the year following the Legislature was asked to grant a charter for a capital of $20,000,000 but the amount was cut down to $10,000,000, under which the company has operated up to the present time. But the enormous development of the business, the necessity for extensions, the purchase of valuable patents, the cost of renewals, and the construction of the long-distance lines require a further addition to the capital invested. The company has spent $2,337,856 up to Jan. 1, 1889, for the construction of the long-distance telephone system, and when further capital is subscribed it is the intention of the company to extend very greatly its long-distance lines. The new work now laid out and actually building—that is, the line from Boston to New York via Providence and the line from Philadelphia to Washington—will cost about $600,000, and other contemplated extensions will require the expenditure of several millions of dollars within a comparatively short time. Something over $2,000,000 will be needed to take up the outstanding bonds payable in a little over a year, and, in round figures, $800,000 will be needed for the new building now in process of construction, a building which the requirements of the business render absolutely necessary. The cost of the long-distance lines with a capacity of 100 wires, averages $5,000 per mile. An additional line is being built from Boston to New York via Providence, and in round numbers it was contemplated to spend from $7,000,000 to $8,000,000 within the next four years.

Francis Blake said that there was no difficulty whatever, in his opinion, in communicating by telephone between Boston and Chicago, and that this view had recently been very strongly corroborated by some experiments made by Professor Cross of the Institute of Technology. That while there was a theoretical limit to the distance the human voice could be carried telephonically, there was practically no limit. Illustrating this, he said that scientists had shown long before Bell invented the telephone, that the transmission of speech by means of electricity was theoretically impossible, but nevertheless Bell had shown it to be practically a possible thing.

Mr. Blake was asked what improvements had been made in transmitters since the first one was invented. He said that the first transmitter is now known as the Bell receiver or hand telephone. Using this as a transmitter in his house, and talking to his laboratory, he had been enabled to make his assistant hear him when at a distance of three feet from the receiving instrument. Using the latest form of transmitter and the same receiving instrument, over the same length of line, he had found no difficulty in making his assistant hear him when the latter was 50 feet from the instrument.

Mr. Angus S. Hibbard, general superintendent of the Long-Distance company, stated that the business of the pay stations very nearly doubled every month, and that although the second line between Boston and New York was necessary to prevent interruption of communication in the event of storms and accidents, it is also necessary to meet the requirements of the business.

Henry L. Higginson, of the firm of Lee, Higginson & Co., appeared to state the advantages which he derived from being able to communicate verbally with his correspondents in New York. He said that it differed materially from communication by telegraph, inasmuch as it afforded the opportunity for a "give and take" conversation, and that just before coming to the state house he had, by means of his long-distance telephone, concluded a very important commercial negotiation which he would not have been willing to trust to the telegraph, and which could not have been carried on by letter, except with great loss of time. He was very certain that the business interests of the country required that this service should be very greatly extended, and that it would be a very great advantage to be able to talk with Chicago as freely as one now talks with New York, Philadelphia and other cities.

There being no more witnesses for the petitioners the chairman asked whether there were any remonstrants who desired to be heard. This question was asked several times, but no one appeared who desired to speak. The clerk of the committee stated that the hearing had been extensively advertised in the newspapers of all the principal cities of the commonwealth.

General P. A. Collins then made a brief closing argument, in which he said that it must be remembered that although the American Bell Telephone Co. was now prosperous the telephone had not by any means always been remunerative. Five years elapsed after the invention of the telephone before any dividend was paid. He said that the company was a Massachusetts corporation; that the money invested in the enterprise was Massa-

chusetts money; that the stock was held in Massachusetts and paid taxes in Massachusetts; that the business was founded upon patents which were the result of the ingenuity and skill of citizens of Massachusetts, and that here in Massachusetts and under its laws the company sought the privilege of further extending the business.

The hearing then closed.

COLLEGE NOTES.

Massachusetts Institute of Technology.

Entrance examinations for 1889 will be held at the Rogers building, 187 Boylston street, Boston, Mass., on Thursday and Friday, May 30th and 31st. A second series, for those unable to be present at that time, will be held on Sept. 24th and 25th. The examinations will begin at 9 A. M., and attendance on both days of one month or the other will be required.

For the convenience of applicants outside New England, and through the courtesy of the gentlemen named, entrance examinations will be held on May 30th and 31st, in the following cities:—

New York, N. Y.—In charge of Assistant Professor Davis R. Dewey, of the Faculty of the Massachusetts Institute of Technology, at the Fifth Avenue Hotel. Address until May 29th, Massachusetts Institute of Technology.

Philadelphia, Pa.—In charge of Assistant Professor Dwight Porter, of the Faculty of the Massachusetts Institute of Technology, at the Lafayette Hotel. Address until May 29th, Massachusetts Institute of Technology.

Montreal, P. Q.—In charge of Assistant Professor Alfred E. Burton, of the Faculty of the Massachusetts Institute of Technology, at the Windsor Hotel. Address until May 29th, Massachusetts Institute of Technology.

Chicago, Ill.—In charge of Professor George Howland, Board of Education Rooms, City Hall, corner of Washington and La Salle streets.

St. Louis, Mo.—In charge of Professor E. H. Long, office of the Superintendent of Public Schools, Seventh and Chestnut streets.

Cincinnati, O.—In charge of Dr. E. E. White, office of the Superintendent of Public Schools, Public Library Building, Vine street.

San Francisco, Cal.—In charge of Willis E. Davis, Esq. (S. B., M. I. T.). Address, 211 Drumm street.

Washington, D. C.—In charge of Professor J. H. Blodgett. Address, United States Geological Survey.

St. Paul, Minn.—In charge of George Weitbrecht, Esq., High School Building.

Pittsburgh, Pa.—In charge of Alfred E. Hunt, Esq. (S. B., M. I. T.), at the Rooms of the Engineers' Society of Western Pennsylvania, 713 Penn building, Seventh and Penn streets.

Kansas City, Mo.—In charge of Professor J. M. Greenwood, at the office of the Board of Education.

The requirements for admission as a regular student in the first year class of the School of Industrial Science are as follows: The applicant must have attained the age of 17 years, and must pass a satisfactory examination in Arithmetic, Algebra, Plane Geometry, French (or German), English Language and Literature, History, and Geography.

Applicants for Advanced Standing must pass the entrance examinations, as before given, and present themselves for further examination at 9 A. M. on the Thursday following the second (September) entrance examinations.

Detailed information in regard to requirements for admission and catalogues of the school, can be obtained by addressing James P. Munroe, secretary, Massachusetts Institute of Technology, Boston, Mass.

Cornell University.

A meeting was held April 10th, by the electrical engineering students who made the recent inspection tour. Several papers of interest were read and a discussion of the valuable notes taken upon the trip took place. The following officers were elected at a meeting of the Electrical Engineering Association of Sibley College. Wednesday, April 10th:—Mr. Allen C. Balch, president; Mr. William K. Archbold, vice-president; Mr. Chas. R. Van Trump, secretary and treasurer.

Mr. W. G. D. Crane, E. E. '87, Cornell, has recently become electrician of the Electric Car Company of America, corner 23d street and Washington avenue, Philadelphia, Pa. Mr. William K. Archbold, E. E., '89, Cornell, has arranged to enter the employ of the Westinghouse Electric Co., Pittsburgh, Pa.

The following are some of the Theses, graduates in electrical engineering at Cornell, for the next commencement:—

W. K. Archbold—*Alternating Currents.*
A. C. Balch—*Tests of Insulation.*
H. E. Barrett—*The Thomson-Houston Dynamo.*
H. E. Boskervill—*Design of an Electric Lighting Plant.*
B. H. Blood—*The Third Brush System of Regulating Dynamos.*
C. R. Van Trump—*Design of an Alternating Current Plant.*
C. L. Cornell—*Alternating Currents.*
J. W. Kirkland—*The Electrical Properties of Phosphor Bronze.*
A. Morston—*Study of the Variation of the Modules of Electricity in Structural Steel.*
L. G. Merrit—*Tests on Brush Storage Batteries.*
J. W. Upp—*Design of Electric Lighting Plant.*
L. H. Parter—*Dynamo Regulations by a Third Brush.*
A. Vickers—*Design of a Plant for Alternating Currents.*
F. N. Waterman—*Insulation Tests of Wire.*
F. G. Schlosser—*Design for an Electric Lighting Plant.*

The executors of the estate of the late Captain Ericsson, in accordance with his wishes, will present to Sibley College, Cornell University, a bust of the great inventor as a memorial. The bust will be a duplicate of the one presented to the King of Sweden.

The electrical outfit of Cornell has recently been augmented by the gift of a new Tesla alternating current motor, which will soon receive a thorough test as to its efficiency. A new Thomson electrical balance has also been added to the laboratory.

Mr. H. J. Ryan delivered a very interesting lecture, April 19, to the Electrical Engineering Association of the University. His subject was "Alternating Current Motors."

I. P. Disney, '88, has entered the employ of the Standard Underground Cable Co., of Pittsburgh, Pa.

C. E. Loomis, '88, has recently left the Mather Co. and is now with the Thomson Electric Welding Co., of Lynn, Mass.

P. P. Barton, '86, is with the Westinghouse Electric Co., Pittsburgh, and will soon be attached to their engineering staff.

Mr. L. B. Marks is making a thorough investigation of electric light carbons, from all of the important carbon manufacturers. Valuable data have already been obtained.

Mr. E. P. Roberts, professor of electrical engineering at Cornell, is about to enter the service of the Brush Electric Co., of Cleveland. His departure from Cornell will be a serious loss to the electrical department of Sibley College.

H. N. Brooks, E. E., '88, has entered the employ of an electrical firm in New York city.

Mr. H. J. Ryan delivered an interesting lecture to the Electrical Engineering Association on Friday, April 26. His subject was, "Alternating Current Motors."

Ohio State University.

A course of instruction in electrical engineering has been conducted at Ohio State University, Columbus, for several years with such success, that it has been determined by the University authorities to establish a separate department with a full course, theoretical and practical, leading to a degree for graduates. The course will cover four years, and will be initiated at the beginning of the next college year in September next. A new building, for which plans and estimates have been perfected, will be erected at once for the exclusive accommodation of the electrical engineering department. The outfit will include a fully equipped machine shop and a complete set of dynamos, motors and lamps, exemplifying machines for constant potential, constant current and alternating current, all to be of commercially working capacity. The course of instruction and training will be directed to impart to the students a full measure of practice as well as a thorough grounding in the theoretical principles of electrical engineering. The department has been planned and will be directed by Dr. B. F. Thomas, professor of physics in the University. Dr. Thomas, whose attainments and enthusiastic interest in electrical science and arts are familiar to electricians, has kept in touch with the practical work of electrical engineers no less than with the constant acquisitions of its science, and his supervision of the new department of Ohio State University is a sufficient guarantee of the quality of the work that will be done there.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The Annual Meeting in May.

The annual meeting of the American Institute of Electrical Engineers will be held May 21st and 22d.

The meeting for the election of officers for the ensuing year and for the transaction of other business will be held at the house of the American Society of Civil Engineers, 127 East 23d street, New York, Tuesday evening, May 21, at 8 P. M.

The morning session of the general meeting for the reading and discussion of professional papers will be held at the same place, beginning at 10 A. M., May 22. A collation will be served at 1 P. M., and the meeting will then reassemble for the afternoon session at the College of the City of New York, No. 17 Lexington avenue, where suitable electrical apparatus will be provided for experiments connected with such papers as require them.

The following papers will be read by the authors: "Modern Views as to the Nature of the Electric Current," with experiments, by Professor H. A. Rowland; "The Inherent Defects of Lead Storage Batteries," by Dr. Louis Duncan; "The Regulation of

Dynamos and Motors," by Dr. Schuyler S. Wheeler; "The Measurement of Telephonic Currents," by Professor Chas. R. Cross; "A Series of Tests on the Life and Efficiency of Incandescent Lamps," by W. H. Peirce, of the Chicago, Burlington & Quincy R. R.; "Some Results with Storage Batteries in Train Lighting, by Alexander S. Brown," of the Pennsylvania R. R.

Also, Professor Elihu Thomson is expected to read a paper treating upon "Magnetism and its Relation to Induced Electromotive Force and Current." Professor Thomson's design is to select typical examples and unfamiliar cases of the relation of a magnetic field to induction in illustration of his general theme.

THE ELECTRIC LIGHT AT THE PARIS EXHIBITION.

M. Hippolyte Fontaine has read a paper on this subject before the International Society of Electricians in Paris, from which we extract the following particulars. The total cost of the exhibition to the French government and town of Paris is estimated at about £2,000,000. There are, in round numbers, 50,000 exhibitors, of whom each will spend on an average £120, representing an additional outlay of £6,000,000, so that the whole cost of the exhibition may be roughly estimated at £8,000,000. The total earning capacity of exhibitions depends, amongst other things, upon the number of hours during which the public has access. If no artificial lighting were used, the total number of hours would amount to 1,620; but by the adoption of the electric light, this number has been increased to 2,520, reducing the cost of the exhibition per hour from nearly £5,000 to a little over £3,000. Although this is a substantial gain wholly due to electric lighting, the administration have not cared to erect the necessary plant at their own cost, or to pay for the light at a fixed rate, as they do with steam, water, gas, &c.; but they have agreed to hand over to the purveyor of the light one-half the entrance money received from visitors in the evening, and which is fixed at two francs on week days and one franc on Sundays. The electric lighting plant has been provided and will be worked by the Electric Lighting Syndicate, which has been formed with a view to make the lighting an international undertaking. The lighting has been divided between a number of firms and systems, and this will afford an excellent opportunity for comparisons. The machinery hall, which has a floor space of 77,000 square meters (or about 19 English acres) and a volume of 2,000,000 cubic meters, will be lighted by arc lamps of various sizes. The largest lamps are arranged in four groups of 12, close under the ridge of the roof. These will be 60 ampere lamps, and will burn 25mm. carbons. Eighty-six 25 ampere lamps are distributed in five longitudinal rows, and suspended about 15m. from the floor. The side galleries of the machinery hall and the stands adjacent to them will be lighted by 276 eight ampere arc lamps suspended 5m. from the floor. The lighting is being undertaken by the following contractors :—

For the 25 Ampere Lamps.

Crompton & Co	24
Maison Ducommun	20
Sautter, Lemmonier & Co	12
Jaspar	11
Société Belge	6
Borssat	5
Société Française de Materiel Agricole	4
Henrion	4

For the 8 Ampere Arc Lamps.

Crompton & Co	79
Maison Ducommun	76
Sautter, Lemmonier & Co	80
Alioth & Co	30
Oerlikon Works	25
Société Française de Materiel Agricole	8
Société Belge	8
Henrion	8
Jaspar	7
Popp & Co	5

In addition to the arc lamps, there will be various installations of glow lamps, contracted for by the following firms :—

Woodhouse & Rawson	8 of 200 c. p.
Garnot	10 of 250 c. p.
Jarriant	369 of 8 c. p.
Crompton	160 of 8 c. p.

The annex devoted to railway exhibits, which comprises nearly 6,000 square meters of surface, is to be lighted by five 25 ampere and thirty 8 ampere arc lamps by M. Borssat, whilst the large central dome will be lighted by the Société Gramme by 48 glow lamps of 500 c. p. Besides the spaces here mentioned, the various other annexes and courts will receive separate installations, but want of space precludes our giving a full list. In the open spaces the lighting will principally be effected by continuous current arc lamps and Jablochkoff candles, and the work is divided between the Paris Edison company, the Rothschild-Marcel-Deprez combination, the Maison Ducommun, and the Société l'Eclairage Electrique, who work the Jablochkoff system. The large fountain which is being erected by Messrs. Galloway, of Manchester, in conjunction with the administration, will be lighted by the Gramme company, of Paris, with 48 arc lamps, requiring about 250 h. p. There will, however, be a second fountain erected by Messrs. Galloway, who are for this purpose utilizing the plant which was in use at the Manchester exhibition, and this fountain will be lighted by eighteen 60 ampere arc lamps. M. Fontaine gives the following table, showing the total amount of light which will be nightly employed :—

Lamps employed.	Units of 1,000 candles.
51 arcs of 60 amperes	510.0
100 " 25 "	350.0
10 " 15 "	20.0
726 " 8 "	726.0
97 Jablochkoff candles	38.8
16 sun lamps	16.0
72 glow lamps of 500 candles	36.0
10 " " 250 "	2.5
3500 " " 10 "	35.0
6500 " " 5 "	32.5
Total	1766.8

In this table we have for simplicity assumed that one carcel is represented by 10 standard candles. Correctly speaking, it is 9.6 candles, and the total amount of light will thus be reduced to about 1,700,000 candles. There will thus be employed in the lighting of the exhibition a candle-power close upon 1¾ millions.—*Industries.*

TELEGRAPH EXTENSION IN FRANCE.

The French Telegraph Administration proposes to join Paris and the suburbs by an electric network, which is to be more important and developed. The first telegraph lines to be constructed with that object in view will be those from the Porte of Courcelles to Lavallois-Perret and from the Porte of Maillot to Puteaux (Quai National). This is to be carried out without the usual legal formalities, and already details of the lines in question have been addressed to the municipalities interested.

ELECTRICAL EXHIBITION AT ST. JOHN, N. B.

The Board of Trade of St. John, N. B., announces that an exhibition of electrical appliances will be held in that city, opening on the first of July next and continuing 10 days or more. The exhibition is planned in connection with the carnival celebrating the union of the cities of St. John and Portland, and the opening of their connection with the Canadian Pacific Railway. Exhibits from the United States are cordially invited by the St. John Board of Trade. Special arrangements are undertaken for the entertainment of representatives of the technical and general press.

NEWSPAPER ELECTRICITY.

The competition between alternating and continuous currents may be called a race between the alternating current motor and the accumulator.

Three hundred miles an hour is the proposed speed for the electric postal railroad of the future.

The sparking of a transformer-wound motor is claimed to be altogether insignificant.—*N. Y. Times.*

CLUB NOTES.

The Electric Club, New York.

At the annual meeting of the Electric Club, April 18th, the postponed resolution amending the by-laws by increasing the dues and membership fee was taken up, and the following increase unanimously voted :—

Commencing May 1st, 1889, resident members will pay an initiation fee of $50; annual dues of $50.

Non-resident members beginning with the same date shall pay an initiation fee of $25; annual dues of $30.

The following-named gentlemen were elected officers of the club for the year beginning May 1st, 1889 :—

President—E. T. Gilliland.

Vice-Presidents—O. E. Madden, Theo. N. Vail, E. N. Dickerson, H. C. Davis.

Secretary—Chas. W. Price.

Treasurer—Willard L. Candee.

Board of Managers—M. W. Goodyear, John A. Seely, H. L. Storke, W. H. Johnstone, A. H. Patterson, Geo. B. Coggeshall, Cyrus O. Baker, Jr., J. C. Tomlinson, Henry A. Reed, J. W. Handren, H. D. Stanley, C. H. Barney and C. E. Stump.

Committee on Membership—Henry Hine, Lieutenant F. W. Toppan, U. S. N., Geo. Worthington, Geo. T. Manson and Henry D. Lyman.

Chicago Electric Club.

The annual meeting of the Chicago Electric Club was held April 18. The following officers were elected :—President, S. A. Barton; vice-president, 1st, H. Ward Leonard; 2d, F. B. Badt;

3d, Alex. Kempt; 4th, D. P. Perry; secretary, W. A. Kreidler; treasurer, F. S. Terry; managers, B. E. Sunny, F. E. Degenhardt, M. A. Knapp, E. Baggott, H. A. Glasier, William Zimmerman, W. M. Lenhart, George B. Bailey, C. K. Giles, E. A. Sperry. Membership committee, C. C. Haskins, W. H. McKinlock, George W. Whitefield, F. W. Parker, J. H. Shay. It was voted to assess each member $10 to aid in furnishing the new club rooms. It was stated that 15 members would contribute $100 each for this purpose.

Harvard Electric Club.

The Harvard Electric Club elected officers as follows, at a meeting held April 17:—President, J. Hale, L. S. S.; 1st vice-president, F. S. Duncan, '90; 2d vice-president, B. H. Rounsaville, L. S. S.; secretary, L. K. Perot, L. S. S.; treasurer, A. N. Baron, '91; librarian, G. T. Page, '92. At the same meeting five new members were admitted, and letters of acceptance of honorary membership were read from Professors John Trowbridge, B. O. Pierce, E. H. Hall, and Dr. Harold Whiting.

ELECTRIC LIGHT AND POWER.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION has removed its head-quarters and office of the secretary from Madison square to 18 Cortlandt street, New York, room 512. The new location will give the secretary, Mr. Allan V. Garratt, more convenient access to the electric light companies, most of which have their offices down-town.

THE SPERRY ELECTRIC CO., of Chicago, the owners of the patents of Mr. Elmer A. Sperry, are drawing attention to the comprehensive arc lighting system of Mr. Sperry, and they have the best wishes of the electrical trade. A pamphlet recently issued embodies in compact and striking form the technical and practical claims made for their apparatus, and presents many features of interest. The list of installations given is extensive, and embraces a number of large office buildings and hotels, as well as central stations.

THE WESTINGHOUSE ELECTRIC CO., during the first half of the present month received orders for alternating current outfit aggregating a capacity of 10,750 lights. These included initial orders from St. Joseph, Mo., 3,000 lights; Newburgh, N. Y., 1,500 lights; Decatur, Ills., 750 lights; Oxford, O., 1,000 lights and a 50-light Waterhouse arc outfit; Wyoming, O., 750 lights; New York, the Safety Light, Heat and Power Co., 3,000 lights. Increase of existing plants,—Washington, Pa., 750 lights. A year ago 79 central stations were using or erecting Westinghouse alternating plants. On the 15th inst. the number had reached 160, with an aggregate capacity of 300,000 16-c. p. lamps.

During the latter half of April the Westinghouse company received orders for alternating current outfits as follows: Jonesborough, Ark., 750 lights; Westerly, R. I., 500 lights; Newark, N. J., 750 lights; Ottawa, Kas., 750 lights; Ashland, N. H., 500 lights; Minneapolis, Minn., 600 lights (increase); Auburn, Me., 750 lights; Traverse City, Mich., 500 lights. The total of orders for the month of April aggregates 15,850 16-c. p. lamps capacity. Total for four months to April 30, 74,000 16 c. p. lamps capacity. About one-third of the central station companies using the Westinghouse system have increased their capacity since starting, in most cases at least doubling their original outfit.

THE THOMSON-HOUSTON ELECTRIC CO. report the following sales of arc and incandescent lamps:—

Adams, Mass., 45 arc; Sanford Woolen Mills, Medway, Mass., 100 inc.; Monroe County Insane Asylum, Rochester, N. Y., 600 inc.; Saxon Woolen Mills, Franklin, Mass., 200 inc.; New England company, Bath, Me., 300 inc.; Buffalo, N. Y., 190 arc.; Lowell, Mass., 1,000 alt.; Leominster, Mass., 50 arc, 600 alt.; Leicester, Mass., 600 alt.; Hudson, N. Y., 45 arc; Portland, Me., 45 arc; Manchester, N. H., 100 arc; Revere, Mass., 600 alt.; Findlay, O., 1,000 alt.; Woonsocket, R. I., 1,000 alt.; Pitman, Mass., 500 alt., 50 arc; Rockland, Me., 30 arc; Savannah, Ga., 250 arc; Malden, Mass., 500 alt.; Upper Sandusky, O., 60 arc; Columbus, Ga., 1,000 alt., 100 arc; Thomasville, Ga, 50 arc; Perry Paine building, Cleveland, O., 1,000 inc.; Falls City Jean and Woolen Mill, Louisville, Ky., 200 inc.; Stearn & Silverman, Wheeling, W. Va., 20 arc; Mowry building, Syracuse, N. Y., 200 inc.; New Haven, Conn., 45 arc; Washington Court House, O., 50 arc; Cambridge, Mass., 1,000 alt.; Hudson River State Hospital, Poughkeepsie, N. Y., 800 inc.; Bedford, Pa., 50 arc, 600 alt.; Stamford, Conn., 1,500 alt.; Fernandina, Fla., 50 arc; New Decatur, Ala., 50 arc; Chester, Pa., 30 arc; H. W. Smith, Bangor, Me., 50 inc.; T. J. Stewart, Milo, Me., 50 inc.; Riverside and Oswego Mills, Providence, R. I., 400 inc.; Morse & Whyte, Cambridge, Mass., 200 inc.; Jewell Milling Co., Brooklyn, N. Y., 200 inc.; James Walker & Co., Basin Mill, Me., 50 inc.; Fort Paine Coal and Iron Co., Fort Paine, Ala., 400 inc.; J. B. Mason, Providence, R. I., 50 inc.

THE THOMSON-HOUSTON ELECTRIC CO. report the following sales of stationary motors:—

Walker and Pratt Manufacturing Co., Boston, 7.5 h. p.; J. H. Kelly, Providence, R. I., 1 h. p.; Georgia Electric Light Co., Atlanta, Ga., 10 h. p.; Master Builders' Association, Boston, 10 h. p.; A. Harris, Providence, 1 h. p.; Bonschur and Holmes, Philadelphia, 1.5 h. p.; H. W. Ladd, Providence, 3 h. p.; W. Shedley, Providence, 1.5 h. p.; J. J. Hillman, Boston, 10 h. p.; Garfield and Proctor Coal Co., Boston, 15 h. p.; Cambridge Shirt Co., Cambridgeport, Mass., 1 h. p.; A. C. Manchester, Providence, 1.5 h. p.; New Bedford Gas Co., New Bedford, Mass, 1.5 h. p.; C. F. Heptonstall, Providence, 3 h. p.; B. F. Haley, Dover, N. H., 1 h. p.; John M. Sweeney, Wheeling, W. Va., 1.5 h. p.; E. L. P. Martin, Providence, 3 h. p.; T. C. Entwistle, Lowell, Mass., 5 h. p.; Minot estate, 39 Court street, Boston., 15 h. p.; Whittier Machine Co., Boston, two motors for elevators, 20 h. p.; Thomson-Houston Electric Light and Power Co., Buffalo, N. Y., 5 h. p.; Wales Manufacturing Co., Syracuse, N. Y., 10 h. p.; St. Catharines Electric Railway Co., St. Catharines, Ont., 5 h. p.

THE growth of the electric motor industry has resulted in bringing out a number of ingenious designs and constructions aiming to secure the maximum efficiency and regulation under all conditions, and the modern motor shows a remarkable advance towards becoming a model machine from the machinist's as well as the electrician's point of view.

The latest claimant for the attention of the trade is the Connecticut Motor Co., of Hartford, Conn., who claim to produce a motor embodying the result of an extensive study and experience in this field. They manufacture shunt wound motors of from one-half to 10 h. p. for constant potential circuits, and announce that motors for constant current lines will shortly follow. The makers have sought to secure harmonious relations and proportions in the electrical and mechanical details of their motor, and claim to have produced a machine that is durable and non-sparking, and of high efficiency under changes of load.

Foreign.

Austria.—The arrangements for the electrical lighting of the Parliament building in Vienna, have lately been completed. The whole hall is now lighted by incandescent lamps. Between the skylight and the roof proper, are 25 large incandescent lamps of 400 c. p. each, which throw a bright yellow-white light over the hall, making the place appear nearly double so bright as was formerly the case by gas lighting. In the second gallery, in addition to these, are 20 candelabra, each with three lamps of 16 c. p. each. The machines and accumulators which furnish the current represent 120 h. p. The insulating of the wires has been carried out in the most careful manner. The principal cable runs through one of the many ventilating pipes over the skylight, so that the expensive decorations on the walls remain uninjured; while for the lamps in the gallery, the wires are carried through the gas pipes which were already there.

France.—The Parisian technical press, it appears, complains that the action of the city government renders impossible the use of electricity as a means of transmission of power, very much as the English electricians accused the electric lighting act of retarding the progress of the electric light in England. The whole question arises from considerations regarding a practicable scheme for the conductors. Of course, special lines or routes for every different purpose are not to be thought of. Especial canals for accommodating pneumatic tubes, pipes and conductors for transmission of power and for lighting, which would be a costly undertaking, appear at last to be not only practicable but also necessary. Something very nearly approaching this, Paris already has in its sewers. In some of these, pipes and conductors have already been successfully set up, but these seem not to have been seen by the council. Still another proposition is made which, in spite of its problematic character, the press heartily supports.

It is proposed that the gas, which is now used for lighting and warming, be used for driving gas motors, and these, in various stations throughout the city be made to drive dynamo machines; the current from these dynamos to be—with comparatively small cost it is said—distributed over the city by means of conductors running in the far reaching sewers with which Paris is so plentifully provided.

Germany.—THE council of Hamburg, has decided to request the senate to lower the price of gas for motor running to 15 pfennig (3.65 cents) per cubic meter. There is now a uniform gas price of 18 pfennig (4.37 cents) per cubic meter, without regard to the use for which the gas is intended.

AT Berlin, the stock company for the manufacture of the "Seel" incandescent lamps, has lately made its statement to the Berlin exchange, and with this opportunity has made public its prospects. The call for incandescent lamps increases from day to day, and the company is compelled to make the most strenuous efforts, even having to run nights, in order to supply the demand.

Their report for 1888, shows the production to be 800 lamps per day. After the completion of the two factories now building—to cost 110,000 marks ($28,000)—the capacity of the plant will be increased to 2,300 lamps per day. The probability of selling all the lamps the factory can furnish, is pretty well assured, since already

contracts for the delivery of 195,000 lamps are closed, against about 100,000 for the whole of last year.

From another source we learn that the patents belonging to this company have been attacked—the principal claimant being the Allgemein Electricitäts Gesellschaft.

PERSONAL MENTION.

MR. C. J. KINTNER has associated himself with Dr. Leonard Paget, of New York, under the firm name of Paget & Kintner, for the purpose of acting as chemical, mechanical and electrical experts, and electrical engineers. Dr. Paget is well known both here and in Europe, as an electrician and chemist, and was for several years, assistant professor of applied electricity in Kings College, England, and associated with Professor Sir Charles Wheatstone. He was also consulting engineer of the Anglo-American Brush Co., and Messrs. Siemens Bros., of London. He is the inventor of the Macraeon storage battery. Messrs. Paget & Kintner purpose acting as electrical and chemical experts in both the Patent Office and courts, and in the rendering of opinions upon all matters of such nature for investors or others. Their office will be at 45 Broadway, where Mr. Kintner has been located for some time.

MR. W. D. SARGENT, vice-president of the National Telephone Association, and general manager of the New York and New Jersey Telephone Co., who has been appointed to take charge of the American telephone exhibit at the Paris Exposition, sailed for his post, on the steamship "La Gascogne," Saturday, April 13. In anticipation of his departure, some 30 of his associates in the telephone field united in giving him a complimentary dinner at the Electric Club, of New York, on the evening of the 11th inst., and this "send off" turned out to be one of the pleasantest affairs of the kind in the memory of those present. Mr. Sargent's numerous friends of the electric fraternity throughout the country who were unable to be present will unite in wishing him a pleasant sojourn across the water, and in hoping that he may safely return—according to his present intention—in time to be present at the Association meeting next September.

MR. GEO. W. BRECK, mechanical draughtsman, who has for some time made a specialty of electrical patent drawings, removed April 20th from 160 Fulton street to 5 Dey street, one door west of Broadway, room 17.

MANUFACTURING AND TRADE NOTES.

THE WILLIAMS ENGINE WORKS are to have a Shaw electric traveling crane for their new shops at Beloit. It will have a span of 40 feet, and be proportioned for a working load of 15 tons, but is to sustain a test load 50 per cent. in excess of this, or 22½ tons without injury. It is being built by Edward P. Allis & Co., of Milwaukee, who have had one of these cranes of 25 tons capacity in successful operation in their foundry for several months.

THE TUCKER ELECTRIC CONSTRUCTION CO., have removed to their new offices, Nos. 14, 16, 18, 20 Whitehall street, opposite the Produce Exchange.

THE ELEKTRON MANUFACTURING CO., on May 1, move their office from New York to their factory in Brooklyn, being fully convinced that this will facilitate their business. Their location in Brooklyn, corner of Jay and Plymouth streets, is only five minutes walk from the bridge, and is, therefore, easily accessible from New York.

The company report that purchasers have been more prompt to appreciate the merits of the Perret motors and dynamos than they expected, and orders have come in of late faster than they could be filled. They are making a considerable increase in their manufacturing facilities, and expect soon to catch up with orders.

THE ANSONIA BRASS AND COPPER CO. issue a circular setting forth the merits of "Tobin bronze" an alloy which is claimed to be remarkable for its high elastic limit, tensile strength, toughness and uniform texture. It is said to be stronger than ordinary mild steel in rods or plates, and finds use in the construction of machines of many kinds. It has already been employed in the construction of phonographs, electric traction machinery, steam pumps, and other machinery.

MESSRS. FLEMING AND KIMBALL, 17 Dey street, New York, have taken the general agency for the Connecticut Motor Co., of Hartford, Conn. This firm also represents in New York the Harrisburg Car Manufacturing Co., makers of automatic engines for electric lighting stations.

THE NATIONAL GALVANIC BATTERY CO., 18 Cortlandt street, New York, are in the market with a new porous cup for which they claim points of merit. The cup is perforated so that no soaking is required, and platinum contacts protect the binding posts and lead from corrosion.

THE CONTINENTAL DYNAMO CO., of 42 Exchange place, New York, are making a dynamo which possesses several interesting features. The field is of the iron-clad type and the mechanical work on the machines we have seen is of the best description.

A. L. BOGART, 22 Union square, issues a new catalogue and price list of electric gas lighting apparatus and electrical supplies, under date of April 1889. Mr. Bogart was one of the early workers in the field of electric gas lighting, and after many years of experience and increasing business offers, in his catalogue, a large variety of apparatus and appliances, adapted to different conditions and requirements, and at a reduced scale of prices.

NEW INCORPORATIONS.

Concord Electric Co., Concord, Mass., T. T. Robins and others. Capital, $20,000.

Steubenville Gas and Electric Co., Steubenville, O. Capital, $300,000.

Turtle Creek Valley Electric Light Co., Harrisburg, Pa. Capital, $50,000.

Provincetown Electric Co., Provincetown, Mass., J. D. Hillard and others. Capital, $15,000.

Advance Illuminating Co., Newark, N. J., Henry C. Rommell and others. Capital, $100,000.

Phoenix Incandescent Lamp Co., Chicago, Ills., A. F. Oppermann and others. Capital, $100,000.

Riggs Electric Traveling Danger Signal Co., St. Paul, Minn., Joseph W. Riggs and others. Capital, $3,000,000.

American Electric Meter Co., Chicago, Ills., John Marder and others. Capital, $200,000.

Sperry Electric Mining Machine Co., Chicago, Ills., Albert L. Sweet and others. Capital, $100,000.

Union Electric Car Co., Portland, Me., Lewis M. Child and others. Capital, $1,000,000.

Moorestown Electric Light, Heat and Power Co., Moorestown, N. J. Capital, $50,000.

Bryan Electric Co., Bryan, Ohio. Capital, $30,000.

Neponset Electric Co., Boston Mass., J. B. Smith and others. Capital, $50,000.

Acme Electric Co., St. Paul, Minn., Chas. F. Diether and others. Capital, $200,000.

San Marcos Electric Light and Power Co., San Marcos, Texas, John Cook and others. Capital, $10,000.

Union Electric Light Co., Franklin, Mass., A. H. Morse and others. Capital, $20,000.

Madison Light and Power Co., Madison, Dak., W. H. Jones and others. Capital, $25,000.

Lebanon Electric Light Co., Lebanon, Ky., John Rubel and others. Capital, $15,000.

Saginaw Electric Light and Power Co., Saginaw, Mich., A. McIntyre and others. Capital, $25,000.

National Electric Traction Co., Detroit, Mich., W. A. Jackson and others. Capital, $100,000.

Keelyn Electric Co., Milwaukee, Wis., James Keelyn and others. Capital, $1,000.

Livingston Electric Light Co., Livingston, Mont., J. Orschel and others. Capital, $25,000.

Harrodsburg Electric Light and Power Co., Harrodsburg, Ky., G. Bohon and others. Capital, $25,000.

Green Bay and Fort Howard Electric Railway and Power Co., Chicago, Ills., H. Ward Leonard and others. Capital, $100,000.

Belleville Electric Light and Power Co., Belleville, Ills., E. Abend and others. Capital, $25,000.

South End Electric Light Co., Chicago, Ills., G. Falkenburg and others. Capital, $30,000.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Allegheny, Pa	Observatory Hill Pass. Ry. Co	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co.	2	3	Thomson-Houston.
Ansonia, Conn.	Derby Horse Ry. Co.	4	1	Thomson-Houston.
Appleton, Wis.	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	20	Daft.
Asheville, N. C.	Asheville Street Railway	3.5	4	Sprague.
Atlantic City, N. J	Pennsylvania R. R. Co	6.5	6	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co.	2	4	Daft.
Binghamton, N. Y.	Washington St., Asylum & Park R. R.	5	8	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., Brookline Branch	11	23	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	15	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co	4	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	1.5	3	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co.	1	3	Daft.

Electric Street Railways in America now in operation.—*Continued.*

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Chattanooga, Tenn...	Chat. Elec. St. Ry. Co......	5	6	Sprague.
Cleveland, Ohio......	East Cleveland Railroad Co.	8	16	Sprague.
Columbus, Ohio......	Columbus Consolidated St. Railway Co...............	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa.....	Davenport Central Street Railway Co......... ..	3.5	9	Sprague.
Danville, Va.....	Danville St. C. Co..........	2	4	Thomson-Houston.
Dayton, Ohio.........	White Line St. R. R. Co ...	9	12	Van Depoele.
Des Moines, Iowa ...	Des Moines B'd G'g Ry. Co.	10	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co ...	4	2	Van Depoele.
Detroit, Mich.........	Highland Park Ry. Co....	3.5	4	Fisher.
Easton, Pa............	Lafayette Traction Co....	1	2	Daft.
Fort Gratiot, Mich...	Gratiot Electric Railway...	2	2	Van Depoele.
Harrisburg, Pa.......	East Harrisburg Pass. Ry. Co.............	7.5	10	Sprague.
Hartford, Conn.......	Hartford and Weathersfield Horse Railroad Co......	3	4	Sprague.
Ithaca, N. Y..	Ithaca Street Railway Co..	1	2	Daft.
Jamaica, N. Y........	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind........	Lafayette Street Ry. Co...	3	9	Sprague.
Lima, Ohio..	The Lima Street Railway Motor and Power Co.....	6	7	Van Depoele.
Los Angelos, Cal....	Los Angelos Elec. Ry. Co.	5	4	Daft.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)...	1	1	Thomson-Houston.
Lynn, Mass......... .	Lynn & Boston R. R. Co. (Highland Line)..... ...	2	1	
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Meriden, Conn.......	New Horse Railroad........	5	12	Daft.
Meriden, Conn.......	Meriden Horse R. R. Co....	5	12	Daft.
Newark, N. J	Essex Co. Pass. Ry. Co...	2.5	4	Daft.
New York, N. Y......	N. Y. & Harlem (Fourth Avenue) R. R. Co...... ..	18.5	10	Julien.
New Orleans, La......	.. ..		1	Daft m'tr and Gibson st'ge battery.
Omaha, Neb..........	Omaha & Council Bluffs Railway and Bridge Co..	9	12	Thomson-Houston.
Pittsburgh, Pa........	Pittsburgh, Knoxville & St. Clair St. Railway..	2.25	4	Daft.
Port Huron, Mich.....	Port Huron Electric Ry....	4	6	Van Depoele.
Reading, Pa...........	East Reading R. R. Co......	2	3	Sprague.
Revere, Mass	Revere Beach Ry. Co.......	1	1	Thomson-Houston.
Richmond, Va........	The Richmond Union Pass. Railway Co.............	13	46	Sprague.
Salem, Mass	Naumkeag Street Ry. Co..	2	6	Sprague.
San Diego, Cal.......	San Diego Street Ry. Co. .	9	4	Henry.
San Jose..............	San Jose & Santa Clara R. R. Co...	10	6	Fischer.
Seattle, Wash. Ter...	Seattle Electric Railway and Power Co...........	5	5	Thomson-Houston.
St. Catherine's, Ont...	St. Catherine's, Merritton & Thorold Street Ry. Co....	7	10	Van Depoele.
St. Joseph, Mo........	St. Jos. Union Pass. Ry. Co.	6	12	Sprague.
St. Joseph, Mo.......	Wyatt Park Railway Co...	10	17	Sprague.
Scranton, Pa.........	The People's Street Ry....	12	20	Sprague.
Scranton, Pa.........	Scranton Suburban Ry. Co.	4	10	Thomson-Houston.
Scranton, Pa.........	Nayang Cross-Town Ry....	1.25	4	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry....	2	4	Thomson-Houston.
Southington, Conn...	Southington & Plantsville Ry. Co.....	2.2	2	Thomson-Houston.
Syracuse, N. Y.......	Third Ward Ry. Co........	4	8	Thomson-Houston.
Steubenville, Ohio....	Steubenville Elec. Ry. Co..	2.5	6	Sprague.
Topeka, Kan.........	Topeka Rapid Transit Co...	14	12	Thomson-Houston.
Washington, D. C....	Eckington & Soldiers' Home Electric Railway Co......	2.7	7	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co......	10	10	Thomson-Houston.
Wichita, Kan.........	Riverside & Suburban Ry. Co...........	6	6	Thomson-Houston.
Wilkesbarre, Pa......	Wilkesbarre & Suburban Street Railway Co	3	7	Sprague.
Wilmington, Del.....	Wilmington City Ry. Co...	3	4	Sprague.
Windsor, Ont.........	Windsor Elec. St. Ry. Co...	2	2	Van Depoele.

Total—Roads............. 69
" **Miles... ....346.15**
" **Motor Cars......512**

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Atlanta, Ga..........	Atlanta & Edgewood St. Ry. Co.........	4.5	4	Thomson-Houston.
Bangor, Me...........	Bangor Street Railway Co..	5	4	Thomson-Houston.
Boston, Mass...... ...	West End St. Ry. Co., City Line, Boylston & Beacon Streets..			Bentley-Knight.
Buffalo, N. Y..	Buffalo, St. Ry. Co.... ..	2.5	4	Sprague.
Cincinnati, O...	Cinc. and Inclined Plane Ry	6	20	Sprague.
Cleveland, O..........	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Cincinnati, O.........	Cincinnati St. Ry. Co......	2.7	8	Thomson-Houston.
Cincinnati, O.........	Colerain Ave. Ry. Co. ...	2.75	8	Thomson-Houston.
Eau Claire, Wis......	Eau Claire St. Ry....	5	6	Sprague.
Erie, Pa...	Erie City Pass. R. R. Co....	12	20	Sprague.
Kansas City, Mo.	Vine St. Ry...		6	Thomson-Houston.
Kansas City, Mo......	Metropolitan St. Ry. Co	2.25	8	
Lynn, Mass..........	Lynn & Boston R. R. Co. (Nahant Line)......... ..	.8	1	Thomson-Houston.
Louisville, Ky	Central Pass. R. R. Co....		10	Thomson-Houston.
Manchester, Va.......	Richmond & Man. Ry. Co .	3.5	10	Sprague.
Marlboro, Mass.......	Marlboro St. Ry. Co.........	3	2	Sprague.
Minneapolis, Minn....	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Newburyport, Mass..	Newburyport & Amesbury Horse Ry. Co............	6	2	Thomson-Houston.
Newton, Mass........	Newton Circuit Line.......	8	10	Thomson-Houston.
Nashville, Tenn......	McGavock & Mt. Vernon St. Ry...........	8	6	Thomson-Houston.

Constructing or Under Contract.—*Continued.*

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
New York, N. Y.. ..	North & East River Ry. Co.	3	20	Bentley-Knight.
North Adams, Mass...	Hoosac Valley Street Ry...	5	6	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	5	20	Thomson-Houston.
Ontario, Cal....... ...	Ontario & San Antonio Heights Ry. Co.....	8	4	Daft.
Ottawa, Ill......... ...		6	8	Thomson-Houston.
Pittsburgh, Pa........	Pittsburgh Suburban Rapid Transit Co................		3	Daft.
Plymouth, Mass......	Plymouth & Kingston Ry. Co.........................	4	3	Thomson-Houston.
Port Chester, N. Y...	P. C. & Rye Beach Street Railway Co...	3	5	Daft.
Portland, Ore........	Williamette Bridge R. R...	1.5	5	Sprague.
Quincy, Mass....... .	Quincy St. Ry..........	5	4	Thomson-Houston.
Richmond, Va.	Richmond City Ry. Co.....	7.5	50	Sprague.
Rochester, N. Y......	Rochester Electric Ry. Co..	7	8	Thomson-Houston.
Salt Lake, Utah......	Salt Lake City R. R. Co...	6.5	10	Sprague.
St. Joseph, Mo.......	People's R. R. Co..........	10	20	Sprague.
St. Joseph, Mo..	Wyatt Park Ry. Co. (Northern Division)........	4.5	9	Sprague.
St. Louis, Mo.........	Lindell Railway Co.......		1	Julien.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio......	Sandusky Electric Ry......	6.75	6	Sprague.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Springfield, Mo......				Fisher.
Stillwater, Minn.. ...	Stillwater Electric St. Ry ..	5	6	Sprague.
Tacoma, Wash. Ter...	Pacific Ave. St. R R.	6	6	Sprague.
Tacoma, Wash. Ter..	Tacoma Ave. St. Ry. Co....	2	4	Sprague.
Wichita, Kan.........	Wichita & Suburban Ry.Co.	7.5	7	Sprague.
Worcester, Mass.....	Worcester & Shrewsbury .	2.7		Daft.

Total—Roads............ 45

Notes.

THE following report of the Cambridge division of the West End Street Railway, Boston—Thomson-Houston electric road—for the month of April has just been received :—

Average number of motor cars in daily service,	8
Round trips of motor cars,	2,720
Time in service, motor cars,	3,232 hours.
Mileage of motor cars,	17,680 miles.
Round trips, one tow car,	2,720
Round trips, two tow cars,	226
Time in service, towed cars,	3,500 hours 30 minutes.
Mileage of towed cars,	19,149 miles.
Total car round trips,	5,666
Total car mileage,	36,829 miles.

Of the above round trips but seven were lost.

This road has a previous record of but nine trips lost out of 1,179.

THE ELECTRICAL ACCUMULATOR Co. proposes to push on in the field of electric traction, and announces its readiness to equip street railways on the two following methods :—

First. The placing of motors, gearing and accumulators on ordinary cars, say 16 or 18 feet long. *Second.* The placing of accumulators on separative or locomotive cars, about 9 feet long, which can be used also as smoking cars, affording seats for about 10 persons.

The locomotive or smoking car need not be built with a regular body, as it requires only truck, platform, seats, and a weather hood, and no windows, upholstering or expensive finish. They will cost from $200 upwards, it is estimated, ready for the motors and batteries.

Their motors are known as the "Edco," and, as now made, are rated at 10 h. p. each, but are capable for brief periods of time of exerting considerably greater power. Each ordinary street car is usually provided with two motors, which are built by the Electro Dynamic Co., of Philadelphia, one of the oldest and most experienced electric motor companies.

A car battery when fully charged is claimed to be capable of propelling an ordinary car loaded with 50 passengers, over a level road, at the rate of 9 or 10 miles an hour, for about 6 hours, allowing for the average car stops and lay-offs at the terminals. The car would therefore require one change of batteries for a day's run of 12 hours. The batteries supply electric light for inside lamps and head lights, and power for signal bells and alarm gongs.

An accumulator car can ascend steeper grades, and can go at a faster rate of speed, either on grades or on a level road, than is possible with horses, but always, of course, with a correspondingly greater expenditure of energy. In case of a single excessive grade on an otherwise level road it may be advisable on the score of economy not to provide power for each car sufficient for surmounting such grade, but to use an auxiliary motor car, or tow horse, as is now customary. Accumulators, like horses, are for brief periods of time, capable of doing many times their safe or normal amount of work ; but also, like horses, any excessive amount of work which they are called upon to do, can only be done at the cost of shortening their life. The Accumulator company furnish the following estimates :—

The cost of a 16-foot car equipped with motors, necessary gearing, and two sets of batteries, will be from $4,500 to $5,000,

according to the character of upholstery and other finish; without accumulators the cost will be about $3,000. The cost of a locomotive smoking car, equipped with batteries, will be about $1,800.

The company is of opinion that it will not be economical to provide a steam and generating plant for less than 10 cars, and say that for this 75 h. p. will be sufficient. Where the locomotive car plan is adopted, 10 h. p. for each passenger car with its tender should be allowed, but in such case the car mileage is proportionately increased.

The uncertainty of estimates on the depreciation of accumulator plants, so far as concerns the batteries themselves, has been perhaps the chief obstacle to a more general introduction of them than has taken place thus far. In respect to this feature, the Electrical Accumulator Co. offers to insure (or renew) the worn out battery plates for an annual charge of 25 per cent. of the list price of the accumulators. This charge is considerably in excess of what they believe will be the actual cost of renewal, but they feel obliged to charge for the risk of accidents over which they have no control, and of carelessness on the part of employés other than their own. Here then is a maximum figure for the item of battery depreciation in an estimate of operating expenses.

One of the cars equipped with the Electrical Accumulator Co.'s batteries and the "Edco" motor, constructed by the Electro Dynamic Co., of Philadelphia, made a very successful trip, April 10th, over the Darby branch of the Traction line in Philadelphia. This particular road was selected for a trial trip owing to the long, steep grades and sharp curves with which it abounds. Grades and curves were readily taken, and a remarkable uniformity of speed was maintained over them.

On a particularly bad piece of track, a sharp curve on a hillside, the car left the track, but by the application of a little more power from the batteries the motors backed the car into place on the rails, and the trip was resumed with but little delay, and without blocking the road.

THE SPRAGUE ELECTRIC RAILWAY AND MOTOR Co. has, during the past month, made contracts to equip two more railways in St. Joseph, Mo. That city was among the earliest to adopt electricity upon its street railroads, and on its Union Passenger Railway demonstrated the manifold advantages of electric power. After that road had been running some time, another St. Joseph railway, the Wyatt Park line, installed a complete equipment of electric cars, which have now been running about six months. There only remained two other railways in St. Joseph, and these two railway companies, through their presidents, have now contracted with the Sprague Electric Railway and Motor Co., which furnished the equipment for the other two St. Joseph roads, for the entire equipments of their lines. These orders amount to 20 cars and over 10 miles of track. Since the Union Passenger and the Wyatt Park lines have been in operation, they have been so extensively patronized that each of these companies have ordered additional equipment of five and nine cars respectively. These orders now make 44 electric cars which are now in operation or have been ordered for the City of St. Joseph alone, with nearly 25 miles of track.

In addition to this remarkable showing in electric railways, the City of St. Joseph has shown uncommon enterprise in installing stationary motors, very many of which are in use for all kinds of industry, and their number is very rapidly increasing.

THE THOMSON-HOUSTON ELECTRIC Co. have lately closed the following street railway contracts:—

Lynn and Boston Railroad Co., Nahant line. This line has 4,869 feet of track, 2 turnouts, maximum gradient of four per cent., and will extend from Central square, Lynn, to the Nahant House, Nahant. One car will be put in operation at first, the power for which will be obtained from the station of the Lynn Electric Light Co.

Newburyport and Amesbury Horse Railway Co., Newburyport, Mass. This line is about 6 miles in length and will operate 2 cars. It is made up almost entirely of curves and grades, the maximum grade being ten per cent. The current will be taken from the Newburyport Electric Light Co. and the Amesbury Electric Light Co.

The Newton circuit line, Newton, Mass. This line will operate 10 cars and is 8 miles in length, maximum gradient of five per cent. It will run from Newton to Watertown on the West End track, and on new track from Watertown to West Newton and Newtonville.

The Plymouth and Kingston Railway Co., Plymouth, Mass. This line is 4 miles in length and will operate 3 cars. The maximum gradient is six per cent. The line will run from Chiltonville through Plymouth to Kingston. On nearly all of the line the bracket method of suspension will be used. The track is nearly all laid.

The Quincy Street Railway, Quincy, Mass. This line will operate 4 cars and is 5 miles in length. It extends from Quincy through Wollaston Heights to the Neponset River. The bracket method of overhead construction will be used.

The company has also received orders for new cars from the Wheeling Railway Co., Wheeling, W. Va.; West End Street Railway Co., Boston, Mass.; Topeka Rapid Transit Co., Topeka, Kan.; Omaha and Council Bluffs Railway and Bridge Co., Omaha, Neb.; Lynn and Boston Street Railway Co., Lynn, Mass.

The Thomson-Houston Electric Co. have constructed a track of about one mile for the Hillside Coal Co. at Scranton, Pa., on which a 40 h. p. mining locomotive is used. This is used for carrying coal, and is capable of hauling about 20 cars loaded with one ton each.

LEGAL NOTES.

STORAGE BATTERY LITIGATION.

In the United States Circuit Court, April 9, Judge Coxe approved of the disclaimer filed by the Electrical Accumulator Co. (see decision of Judge Coxe in the suit of the Electrical Accumulator Co. *vs.* the Julien Electric Co. in THE ELECTRICAL ENGINEER for April, 1889), and formulated the decree and injunction restraining the Julien Electric Co., their officers, agents and workmen from further manufacture, use or sale of secondary batteries of the Faure type, in which the active material is applied to the support in the form of a paint, paste or cement.

INCANDESCENT LAMP LITIGATION.

The important suit of the Consolidated Electric Light Co. against the McKeesport Light Co. is expected to be ready for hearing at the May term of the United States Circuit Court in Pittsburgh. The real parties in interest, as is well known, are the Westinghouse Electric Co. and the Edison Electric Light Co., and the suit is brought upon the "fibrous carbon" patent of Sawyer and Man, for which the patent application was filed January 9, 1880. The patent issued May 12, 1885, but not until after a prolonged and vigorous contest with Edison in the Patent Office, on the question of priority of invention, which was finally decided by the commissioner in favor of Sawyer and Man. The infringement alleged consists in the use by the defendants of an incandescent conductor for an electric lamp "of carbonized fibrous or textile material, and of an arch or horseshoe shape," a device which is employed in nearly every incandescent lamp in this country, including, no doubt, all those which have been manufactured by the Edison company since 1880. Considering the vast importance of the interests involved, and the immense volume of testimony which has been taken on both sides, this suit has been pushed forward with unexampled rapidity, an imposing array of eminent counsel being employed in taking the evidence and managing the case. This action was instituted on December 8, 1887, and the testimony was closed on the 4th of February last, but upon a motion being made by the complainant to set a day for hearing, the Edison company moved to reopen the proceedings for the introduction of additional testimony. The court after hearing the motion, granted the defendant one month to take further testimony and the complainant another month to reply. Both sides during this brief interval exerted themselves strenuously to strengthen their respective positions, and it is probable that in the annals of patent litigation no instance is on record of so large an amount of testimony being taken in so short a space of time. The evidence is now all in, and the case will undoubtedly be heard at Pittsburgh early in May. Its decision cannot, in any event, fail to have a very important influence on the future of incandescent lighting interests in this country.

A DECISION IN THE SUIT OF THE WESTERN UNION TELEGRAPH CO. AGAINST THE MAYOR AND THE BOARD OF ELECTRICAL CONTROL OF NEW YORK.

Poles and Wires must Come Down in Streets where Subways are Provided, but Wires may Remain on the Elevated Railroad Structures.

Judge Wallace in the United States Circuit Court handed down his decision, April 12, in the case of the Western Union Telegraph Co. against the Mayor and the Board of Electrical Control, in which the company asked for an order restraining the latter from interfering with the poles and wires of the Western Union company in this city.

The decision vacates the temporary injunction granted upon the application of the Telegraph company, March 29, but enjoins the Mayor and Board of Electrical Control from any interference with complainant's use of structures of the Manhattan Railroad Co. The principal points of the decision of Judge Wallace are given herewith.

This case presents the general question whether certain acts of the municipal authorities of the City of New York respecting

matters of grave local concern, done or about to be done pursuant to powers devolved upon them by the Legislature of the state, are such an invasion of the paramount authority of the National Government as to render them unwarranted. The mere statement of this proposition shows that the complainant has properly invoked the jurisdiction of this court, and has a right to rely upon its interposition by injunction, if the acts of the defendants are thus unwarranted, are injurious to the complainant, and are of a nature revocable by cause of equity.

Telegraph companies that have accepted the restrictions of the law of Congress of July 24, 1866 (title 65, United States Revised Statutes), become, as to government, business agencies of the general government, and are given the privilege to "construct, maintain, and operate" lines of telegraph over and along any post-road of the United States, but not so as to interfere with "the ordinary travel" on such roads. All the streets of the City of New York are post-roads, because they are letter-carriers' routes, and all railroads are post-roads (Revised Statutes, sec. 3,364). The complainant accepted the provisions of the law of Congress in 1867.

A telegraph company occupies the same relation to commerce as a carrier of messages that a railroad company does as a carrier of goods. Both companies are instruments of commerce, and their business is commerce itself. Telegraph companies are subject to the regulating power of Congress in respect to their foreign and inter-state commerce, and this power resides exclusively in Congress. The complainant has been engaged in inter-state and foreign commerce.

In the course of its operations the complainant has lawfully erected its poles and strung its wires in and along the streets of New York city, which, as has been stated, are post-roads of the United States; and it has also put up and now maintains over and along other streets a number of wires upon the structures of the Manhattan Railway Co., an elevated railway of the city, also a post-road, pursuant to a lease from the railway company. The defendants (the Mayor and Board of Electrical Control), assuming to proceed by the sanction and mandate of certain acts of the state Legislature have compelled the complainant to remove its poles and wires from some of the streets, and have notified it to remove them from other streets, and to remove its wires from the structures of the elevated railway, and they purpose if the complainant fails to comply with these requirements to remove the poles and wires themselves. Under these circumstances the complainant asks this court to examine the authority under which this destruction of its property is threatened, and determine whether there is any justification in law for acts which apparently invade the privilege to maintain and operate its lines upon the post-roads of the United States, interfere with its operations as a government agent, and interrupt and impede the discharge of its functions as an instrument of inter-state and foreign commerce.

THE COMPANY UNDER FEDERAL PROTECTION.

It is not open to discussion that the complainant is protected by the national authority against any encroachment under state authority upon the rights and immunities expressly granted to it by the act of Congress, or which it enjoys in its dual capacity as an agent of the general government and an instrument of inter-state and foreign commerce. Speaking of the privilege conferred upon telegraphic companies by the act of Congress the Supreme Court of the United States, in Pensacola Telegraph Co. *vs.* Western Union Telegraph Co. (96 U. S., I, II), used this language:—

"It gives no foreign corporation the right to enter upon private property without the consent of the owner and erect necessary structures for its business; but it does not provide that whenever the consent of the owner is obtained no state legislation shall prevent the occupation of post-roads for telegraph purposes by such corporations as are willing to avail themselves of its privileges." Indeed, the language of one of the very latest opinions of that court upon the question of the power of the state to interfere with the right of the telegraph company to maintain and operate its lines along a post-road, applies to the specific facts of this case, and if literally interpreted, would control the present decision. The question before the court was as to the power of the state to tax the real and personal property within the state of the telegraph company which had accepted the provisions of the act of Congress; but the court, while holding that the privilege granted did not exempt the telegraph company from such taxation, said: "While the state could not interfere by any specific statute to prevent a corporation from placing its lines along a post-road or stop the use of them after they were placed there, nevertheless, the company receiving the benefit of the laws of the state for the protection of its property and its rights is liable to be taxed upon its real or personal property as any other person would be." (Telegraph Company *vs.* Massachusetts, 125 S. N. 530, 548.)

Concerning the immunity of the complainant as an agent of the general government for the transaction of government business for an unwarranted interference through state legislation with its operations, the doctrine first enunciated in McCullough *vs.* the State of Maryland (14 Wheat. Rep., 316) and reiterated in subsequent adjudications whenever the question has arisen, is familiar that the states have no power by taxation or otherwise to retard, impede, burden, or in any manner control the agencies of the Federal Government, and they are exempted from the effect of state legislation so far as that legislation may interfere with or impair their efficiency in performing the functions by which they are designed to serve the government.

Nevertheless, persons and corporations enjoying grants and privileges from the United States, exercising federal agencies, and engaging in inter-state commerce, are not beyond the operation of the laws of the state in which they reside or carry on their business; and it is only when these laws incapacitate or unreasonably impede them in the exercise of their federal privileges or duties, and transcend the powers which each state possesses over its purely domestic affairs, whether of police or internal commerce, that they invade the natural jurisdiction. This doctrine is well expressed in the words of the Supreme Court in Patterson *vs.* Kentucky (97 U. S. 501, 504). The statutes which the defendants are proceeding to enforce unquestionably belong in the category of police regulations, the power to establish which has been left to the individual states. But statutes of this class may sometimes entrench upon the federal jurisdiction and their provisions extend beyond a just regulation of rights for the public good, and unreasonably charge or burden the privileges which the national authority conserves they cease to be operative. The state, when providing by legislation for the protection of the public health, the public morals, or the public safety is subject to the paramount authority of the Constitution of the United States, and may not violate the rights secured or guaranteed by that instrument or interfere with the execution of the powers certified to the general government. Maybe *vs.* Kansas (123 U. S. 623, 663).

THE PRINCIPLES APPLIED.

Applying these principles, it is now to be considered whether the statutes in question or the acts of the defendants under them can be defended under the state power of police regulation, or whether what is proposed to be done exceeds in any respect the boundaries of legitimate regulation and encroaches upon the rights of the complainant founded upon the law of Congress or incidental to the nature of its commerce.

Judge Wallace here considers the state legislation on which the acts of the Mayor and the Board of Electrical Control are based, and then continues:

It was said of the acts of 1884 and 1885 by the Court of Appeals (People *vs.* Squire, 107 N. Y., 593) that they sprang out of a great evil which, in recent times, has grown up and afflicted large cities by the multiplication of rival and competing companies, organized for the purpose of distributing light, heat, water, the transportation of freight and passengers, and facilitating communication between distant points, and which require in their enterprises the occupation of not only the surface and air above the streets, but indefinite space underground. This evil had become so great that every large city was covered with a network of cables and wires attached to poles, houses, buildings, and elevated structures, bringing danger, inconvenience, and annoyance to the public. The necessity of a remedy for these public annoyances had long been felt, and it finally culminated in the enactment of the several statutes referred to. These statutes were obviously intended to restrain and control, as far as practicable, the evils alluded to, by requiring all such wires to be placed underground in such cities, and be subject to the control and supervision of local officers who could reconcile and harmonize the claims of conflicting companies, and obviate in some degree the evils which had grown to be almost, if not quite, intolerable to the public.

THE STATE ACT OF 1887 HELD VALID.

The act of 1887 by validating the contract between the Commissioners and Subway company in effect incorporated the terms of that contract into its provisions But the statute is none the less an exercise of the police power, and within the competency of the Legislature, because of the special privileges given to the Subway company. It has been urged that in effect this statute confiscates property rights of the complainant and other companies owning electric wires, by depriving them of their easements for the benefit of the Subway company, and, therefore, cannot be sustained as an exercise of police power. But in the Slaughter House cases (16 Wall, 36) the Supreme Court upheld a statute far more obnoxious to these objections than the present act.

It has also been objected to the act of 1887, that it contravenes Section 16 of Article III. of the State Constitution prohibiting the Legislature from passing any local bill granting to any corporation, any exclusive privilege, immunity, or franchise. Without intending to intimate that such a question is properly to be considered by this court in the present case, it is proper to say that the objection seems to be without substance. There is nothing in the contract with the Subway company that precludes the Commissioners from building subways, or entering into contracts with other companies for building them, similar to the one made by the Subway company. The contract only extends to

such subways as the Commissioners shall direct the Subway company to build, and it provides in express terms that nothing in it shall be construed as granting to the Subway company any exclusive privilege or franchise.

THE QUESTION TO BE DECIDED.

The question then is whether or not these statutes unreasonably abridge or burden privileges and immunities which the complainant derives from the general government. In whatever language a statute may be framed, its purpose must be determined by its natural and reasonable effect; and these statutes are to be judged by the extent of the powers which they confer, and treated as police regulations only to the extent to which their operations can be justified by the police power of the state. Undoubtedly in carrying them into effect the complainant will be subjected to great expense, temporary interruption of its business, and possibly to permanent inconvenience and loss in conducting its business. But, after all, the question is merely one of the reasonableness of the regulation, and whether the losses and inconveniences to which the complainants may be subjected are not such as may justly be exacted of every citizen or property-owner for their common good. It is a settled principle, growing out of the nature of well-ordered society, that every holder of property, however absolute and unqualified may be his title, holds it under the implied liability that his use of it shall not be injurious to the equal enjoyment of others having an equal right to the enjoyment of their property, nor injurious to the rights of the community.

The privilege to maintain telegraph wires "over and along" post-roads is not to be construed so literally as to exclude regulations by the state respecting location and mode of construction and maintenance which public interests demand but should be construed as intended by Congress, to grant an easement affording telegraph companies all necessary facilities, and which should be to that extent beyond the hostile legislation by the states.

Thus the grant is no more invaded when the regulation requires the wires to be placed in conduits underground than it would be if they were required to be placed in conduits along the surface of the streets; and when this becomes necessary for the comfort and safety of the community such a regulation is as legitimate as one would be prescribing that the poles should be of a uniform or designated height, or should be located at designated places along the streets.

THE ELEVATED ROAD STRUCTURES.

* * * There is serious doubt whether the powers conferred by the statutes in the case, are not migratory to the extent that they permit the complainant to be deprived of its right to maintain its wires upon the structures of the elevated railway. That railway is an independent post-road of the United States, in legal contemplation, carved out of the streets upon which its structures are erected; and state legislation, under whatever power it may be classified, is impotent to destroy the privilege given by the act of Congress. The power to remove the wires altogether from these structures and to refuse to permit them to be kept there under any circumstances, is not regulation, but is equivalent to a complete denial of the privilege.

Judge Wallace said further that the complainant alleges that the subways are insufficient and defective to a degree that will seriously affect the workings of its wires. The defendants deny this averment. The defendants, he said, were certainly not acting *mala fide*.

The decision concludes as follows :—

The well settled doctrine concerning the exercise of duties by public officers is that so long as they confine themselves to such as are confided to them by law the court will not interfere to see whether they are acting wisely or judiciously. An order will be entered denying an injunction and vacating the stay heretofore granted as respects the removal of the complainant's poles and wires from the streets, and granting an injunction against any interference by the defendants with the complainant's use of the structures of the Manhattan Railroad Co. for operating and maintaining its lines.

DECISION OF THE COMMISSIONER OF PATENTS IN AN IMPORTANT ELECTRIC RAILWAY INTERFERENCE CASE.

Priority Awarded to Stephen D. Field.

GREEN *vs.* HALL *vs.* SIEMENS *vs.* FIELD.

Decided March 6, 1889.

1. *Evidence of Invention in Foreign Country.*
Evidence of invention in a foreign country cannot be received in an interference proceeding unless such evidence is in the form of a publication or patent, or is for the purpose of showing that some one of the contestants is not an original inventor.

2. *Priority with Inventor who Reduces to Practice.*
The purpose of the law is to benefit the public as well as to protect the inventor, and the inventor who reduces his invention to practice in such a complete way that he at once perfects it as an invention, and at the same time practically demonstrates its utility, is clearly to be preferred to one who merely made hints and suggestions to others and failed himself to act upon them.

3. *Continuing Applications.*
A second application cannot legally be considered a continuation of a first or earlier application by the same inventor unless it contains *the same invention.*

4. *Models not Evidence of Reduction to Practice.*
It is well-settled law that a working model designed and intended as such, is not a reduction to practice. Mere working models, allowed to rest in oblivion for many years, will not prevail to establish priority when application for patent is delayed and not filed until after another and more diligent inventor has entered the same field of invention and established his claim as an independent inventor.

APPEAL from Examiners-in-Chief.

ELECTRIC RAILWAYS.

Application of Geo. F. Green filed May 15, 1886, No. 202,287. Application of Thomas Hall filed July 22, 1885, No. 172,325. Application of Ernst W. Siemens filed October 25, 1884, No. 146,473. Application of Stephen D. Field filed March 10, 1880, No. 4,752.

Mr. R. D. O. Smith and *Mr. G. W. Dyer* for Green.

Mr. E. N. Dickerson and *Messrs. Foster & Freeman* for Hall.

Mr. C. S. Whitman for Siemens.

Mr. F. L. Pope, Mr. F. W. Whitridge, and *Messrs. Marble & Mason* for Field.

HALL, *Commissioner:*

The issue in controversy is as follows :—

The combination of a stationary dynamo-electric generator driven by a suitable motor, a circuit of conductors composed in part of an insulated or detached section of the line of rails of a railroad track, a wheeled vehicle movable upon or along said section of track, an electro-magnetic motor mounted upon said vehicle for propelling the same and included in said circuit of conductors, and a circuit-controlling device placed upon said vehicle.

In order to adjudicate the rights of the parties involved in this contest it will be necessary to give an interpretation to the issue, inasmuch as the various contestants have adopted several diverse views of the meaning of the subject-matter in controversy.

The principal points of difference relate to the interpretation of the words "stationary dynamo-electric generator," occurring in the first line of the issue, and the words "circuit-controlling device," appearing in the last line of the same.

A comparison of the different applications, including both their specifications and drawings, will throw important light upon this question, because the intention of the examiner who declared the interference must be construed to have been to follow the rules, and therefore he must have regarded each application as at least exhibiting every element of the invention which he declared formed the basis for the interference.

It is contended by one of the contestants that the term "stationary dynamo-electric generator" cannot be held to include the ordinary magneto-electric generator, but is limited to a special form of self-exciting generator, such as was invented by Siemens and is employed by him and also by Field and Green. This construction does not harmonize with the declaration of interference, for Hall certainly could not be involved if we accept the restricted definition of dynamo-electric generator. Another circumstance which is useful in this connection is the history of the applications, considered individually, before the interference was declared. It appears that Field was rejected upon certain patents and his case appealed to the examiners-in-chief, who, in comparing his invention with the references, analyzed the claim to the extent of dividing it into five portions or elements, one of which was a "stationary dynamo-electric generator." The references showed magneto-electric generators and the board found no fault with their pertinency on this account, but pointed out the difference as consisting in the circuit-controller, which they alleged was the essential feature lacked by the patents cited against the application. Thus we see the patentability of the claim was not made to depend upon a restricted meaning of the term "dynamo-electric generator." Furthermore, some of the highest authorities use the expression "dynamo-electric generator" as a generic one, including all kinds of magneto-generators. This is especially so in the noted work on dynamo-electric generators by Thomson. In view of these considerations I am compelled to hold that the expression is generic and covers all forms of magneto-electric generators.

In regard to the term "circuit-controller" Siemens wishes it to be defined as a device which not only makes, breaks, and reverses the circuit, but also modifies the *current*, as, for instance, in its strength or in other particulars. Such an interpretation would also seem to be antagonistic to the theory of the examiner in declaring the interference, for the reason that neither Hall nor Field has any such arrangement. Besides, this is not the usual interpretation of the expression. At the time of the declaration of this interference it was quite common for circuit-breakers and circuit-makers to be included under the generic title of circuit-controllers, and I see no evidence in the record which leads me to believe that a more narrow definition was intended. In discussing

the question of priority I shall therefore consider the term "dynamo-electric generator" as a broad one, designed to include magneto electric generators, and the term "circuit-controller" as including devices for making and breaking the circuit and reversing the same.

In the view I take of this case it will facilitate the arrival at a conclusion to find the dates of invention which can be allowed Field and compare the dates of his competitors with them. On the 21st of May, 1879, Field filed a caveat which, as I view it, fully disclosed the invention in controversy, and this date may therefore be given him as his date of conception. It appears that this caveat was renewed within the year and a short time after renewal—to wit, on the 10th of March, 1880—Field's application was filed. The testimony also shows that Field's conception was disclosed to Mr. Pope sometime previous to the filing of the application with a view of having him prepare an application. but owing to press of business and other reasons Mr. Pope did nothing with it for some time. It certainly is clear that no negligence on the part of Field in filing his application is made out, and as under the decisions an application must be held to be a constructive completion of the invention it results that Field is entitled to carry the date of his invention back to the time of the filing of his caveat. It is furthermore proven that in 1881 Field constructed a railway comprising the elements called for by the issue, and that in 1883 still another railway embodying his invention was constructed and proved a commercial success.

Siemens cannot, under the statute, be permitted to give evidence of having invented the subject-matter of the interference in a foreign country, unless such evidence is in the form of a publication or patent, or is for the purpose of showing that some one of the contestants is not an original inventor. It is fairly shown that no one of the opponents of Siemens gained his knowledge of the invention from the efforts of Siemens in a foreign country, and therefore this branch of Siemens's case fails. The date of the publications of Siemens is later than that found as Field's date of invention, and consequently, as between Field and Siemens, Field must be adjudged to be the prior inventor.

Green, at least as early as the winter of 1874-'5, put in operation a kind of electric railroad having some of the features embraced in the claim in controversy, but lacking the dynamo-electric generator. Instead of the dynamo-electric generator Green at this time employed a battery. In 1878 Green operated publicly a larger-sized railroad with car and electrical apparatus, but in this also he employed a battery as a generator. In August, 1879. Green filed an application for a patent upon his electric-railway invention, but in this also he showed a battery as the generator. It is in evidence that at each of these experiments Green suggested that it might be well to use a dynamo-electric generator instead of the battery; yet he seemed merely to have this idea and made no attempt to put it into practical operation. No matter what the difficulties were which influenced him, still all practical manifestations of his invention, both in the form of experiments and in the form of his application, resulted in the illustration of a battery rather than a dynamo. It is true that in the application it was broadly stated that any known and suitable source of electricity might be employed; but the form which he actually did employ up to this time seemed in every instance to be the battery. I do not believe that these mere suggestions to various persons that he might use a dynamo instead of a battery can be taken to indicate a conception of the invention within the meaning of the law, or that it can be accepted as adequate proof of anticipation of inventions like those made by Field and Siemens, the practicability of which was clearly demonstrated by expensive and difficult experiments. The purpose of the law was to benefit the public, as well as to protect the inventor, and the man who reduced his invention to practice in such a complete way that he at once perfected it as an invention and at the same time demonstrated its utility in a practical sense is clearly to be preferred to one who rested in hints or suggestions to others and failed himself to act upon the same. I think Green's application is to be construed in the light of his acts, in consonance with the rule which a learned and eminent justice announced when he said:—

> Tell me how the parties acted under the contract and I will tell you what they meant by it

Some years after the filing of his first application Green requested to be included in an interference, but was excluded for the very reason that his application did not contain a dynamo, as originally filed, and that the amendment which brought in such dynamo was improper because it involved new matter. This action was sustained by the commissioner, and I am unable to concur in the reasoning of the examiners-in-chief, who in the face of this decision, seemed to construe such application as involving an interference and to hold that Green—

> Has a right to rest upon that application and the action of the Office upon it as evidence of his having disclosed the invention therein at that time.

In May, 1886, Green filed another application in which a dynamo-electric generator was specifically shown and described; but manifestly, in view of the decision of the commissioner, before referred to, that the old application did not properly include any such style of generator, this later application is an entirely independent one. I cannot concur in the proposition of the examiners-in-chief that "while this last application cannot properly be considered a division of the first, yet it is evidently a continuation of it." Legally it cannot be regarded as a continuation of the first application unless it contains *the same* invention The earliest date which can be found for Green is May 15, 1886, which is the date of his second application.

Hall, the last party to be considered herein, claims to have made the invention at a very early date and produced certain publications and models as tangible proof of that fact. As to the Hall Exhibit No. 5, it may be said that the illustration is entirely insufficient, for the reason that it contains no intrinsic evidence that the source of electricity operating the electro-magnetic motor was a stationary dynamo-electric machine or a magneto-electric machine. In reference to the various models it must be said that they were not reductions to practice in any proper sense of that expression. It is not merely a question of size, as counsel for Hall ingeniously put it, but a question of design and purpose. Hall's models were illustrative, like drawings. They were intended to exemplify his theories and not carry them into effect. It is alleged by counsel for Hall that these models could be made practically useful for carrying parcels, letters, and the like, and were of a size sufficient to be used upon a railway in a cash-carrier system; but the point is that there is not sufficient evidence that they were intended at the time they were constructed to accomplish these ends. The purposes for which they were sold and the uses to which they were put with Hall's knowledge are not such as would carry out his counsel's theory. Philosophical laboratories and learned professors rather than commercial houses and business men received and employed them. It is well-settled law that a working model, designed and intended as such, is not a reduction to practice. Hall's devices manifestly were mere working models and nothing more. After more than a score of years had passed the efforts of others called to Hall's mind his former experience, and he then concluded to file his application and claim the invention as his own.

In the decision of Gaylord *vs.* Wilder the Supreme Court of the United States have put their condemnation upon a case of a similar character, but much stronger than is the case of Hall, for in the court case the structure which had been allowed to rest in oblivion for many years was a completed full-size structure and not a mere illustrative model. I feel constrained to hold that Hall does not anticipate Field.

Judgment of priority must, therefore, be rendered in favor of Stephen D. Field. I am impressed, however, with the similarity between the invention involved in this interference and that set forth in the British patent to Clark, to which the examiners-in-chief have called my attention and which has also been brought before me by certain motions, and I therefore direct the case of Field to be returned to the primary examiner, who will consider whether the invention covered therein is patentable in view of Clark's patent, taken in connection with the other state of the art.

There remain to be considered the motions to dissolve this interference on the ground that no interference in fact exists, or that some of the parties were improperly included therein. The remarks I have heretofore made render it unnecessary for me to consider these questions at length. I merely decide that an interference did exist at the time the examiner declared the same and the parties involved were properly included.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From March 19, to April 16, 1889 (inclusive).

Alarms and Signals:—*Coupling and Automatic Circuit-Breaker for Fire-Alarm Circuits*, J. J. Cannan, 399,738. *Electric Alarm-Signal for Cables*, W. H. Woodring and C. S. Gilbert, 400,028, March 19. *Annunciator*, I. S. Bunker, 400,050. *Push Button*, J. H. Lehman, 400,232. *Electric Burglar Alarm*, J. Y. McKinney, 400,239. *Hotel-Call*, E. J. Colby, 400,304. *Thermostat*, E. H. Davis and R. Westervelt, 400,312, March 26. *Alarm System*, C. A. Cox and J. F. Cox, 400,750, April 2. *Thermal Circuit-Closer for Fire-Alarms*, A. C. Iwanowski, 400,917. *Electrical Night-Signaling Apparatus*, E. Kaselowsky, 401,035. *Electrical Call Bell*, J. G. Noyes, 401,296, April 9.

Clocks:—*Electric Self-Winding Time-Piece*, M. Carranza and J. M. Tinoco, 401,006. *Electric Winding for Torsion-Pendulum Clocks*, H. Rabe, 401,065, April 9.

Conductors, Insulators, Supports and Systems:—*Electric Conductor*, A. A. Brooks, 399,826, March 19. *Electric Conduit*, H. A. Chase, 400,300. *Method of Constructing Underground Conduits*, W. C. Cranmer and S. W.

Arnold, 400,308, March 26. *Telegraph-Wire Carrier*, R. S. Donaldson, 400,552. *Insulating Pipe-Coupling*, F. C. Rockwell, 400,600. *Art of Splicing Cables*, J. Collins, 400,748. *Underground Conduit*, P. R. Greene, 400,764, April 2. *Leading-in Apparatus for Conduits*, J. A. Seely, 400,958. *Insulating and Coating Compound*, A. De Figaniere, 401,014. *Tube or Conduit*, G. H. Gillette and K. C. Gillette, 401,154. *Conduit for Electrical Conductors*, same, 401,155. *Apparatus for Laying Electrical Conductors*, W. F. Smith, 401,225. *Splicing Device*, J. C. Basel, 401,244, April 9. *Pole and Tower*, J. W. Davy, 401,338, April 16.

Distribution:—*Electrical Distribution by Secondary Batteries*, F. King, 399,-755, March 19. *Method of Detecting Grounds, in an Electric Distributing System*, E. M. Bentley, 400,181. *Electric Distribution by Storage Batteries*, S. C. C. Currie, 400,395, March 26. *Transfer System of Electric Distribution*, E. W. Rice, Jr., 400,486. *Apparatus for Regulating Current or Potential in Secondary of Transformers*, E. Thomson, 400,515. *Method of Regulating Current or Potential in Secondary of Transformers*, same, 400,516. *Distribution of Electricity by Secondary Batteries*, W. W. Griscom, 400,843. *Secondary Generator for the Conversion of Electrical Energy by Induction*, W. Lowrie and C. J. Hall, 400,862, April 2. *System of Transmitting and Distributing Electricity*, S. C. C. Currie, 401,255, April 9. *Distribution of Electric Currents*, E. Thomson, 401,608, April 16.

Dynamos and Motors:—*Dynamo-Electric Machine*, J. W. Balet, 399,646. E. Thomson, 399,800. *Alternate-Current Inductor*, E. Thomson and M. J. Wightman, 399,801, March 19. *Dynamo-Electric Machine*, W. L. Silvey, 400,-130. *Electric Motor*, E. H. Davis and R. Westervelt, 400,311. *Regulator for Electric Motors*, R. S. Dobbie, 400,315. *Magneto-Electric Generator*, N. B. Ginochio, 400,327, March 26. *Prevention of Sparking in Electric Motors and Generators*, D. Higham, 400,680. *Alternating Current Electric Reciprocating Engine*, C. J. Van Depoele, 400,809. *Dynamo-Electric Machine*, J. B. Entz, 400,838, April 2. *Regulation of Electric Motors*, F. Bain, 400,890. *Alternating Current Electric Motor*, E. Thomson, 400,971. *Armature for Dynamo Electric Machine*, same, 400,973. *Internal Combustion Thermo-Dynamic Motor*, A. Hargreaves, 401,161. *Combined Mechanical and Electro Magnetic Motor*, C. A. Randall, 401,207. *Regulator for Dynamo-Electric Machines*, C. J. Van Depoele, 401,230. *Reciprocating Electric Engine System*, same, 401,231. *Dynamo or Magneto-Electric Machine*, E. Weston, 401,317. *Dynamo-Electric Machine*, same, 401,318, April 9. *Method of Operating Electro-Magnetic Motors*, N. Tesla, 401,520. *Dynamo-Armature*, C. O. C. Billberg, 401,632. *Dynamo-Electric Machine*, E. Weston, 401,-668, and 401,669, April 16.

Galvanic Batteries:—*Galvanic Battery*, C. E. Kammeyer, 400,088; F. Shaw, 400,126; A. Imschenetzky, 400,215. *Voltaic Battery*, I. Kitsee, 400,224, 400,225 and 400,227. *Galvanic Battery*, E. Liebert and S. A. Rosenthal, 400,235, March 26; E. H. Crosby, 400,430, April 2; J. H. Phalan, 401,059, April 9. *Process of Making Battery Zincs*, H. G. Farr, 401,338, April 16.

Ignition:—*Circuit-Closing Device for Electrical Torpedo-Fuses*, J. W. Graydon, 399,876. *Electrical Fuse for Ordnance-Shells*, same, 399,879, March 19. *Electric Gas Lighter*, J. Y. Parke, 400,479, April 2. *Electric Gas-Lighting Device*, D. Rousseau, 400,492, April 2. *Electric Gas-Lighting Burner*, J. Geary, 401,153, April 9.

Lamps and Appurtenances:—*Incandescent Electric-Lamp Socket*, C. E. Egan, 399,748. *Electric Light Support*, B. Schardt and G. Jones, 399,786, March 19. *Switch-Stand for Dynamo-Stations*, R. E. Stewart, 400,139. *Electric Arc Lamp*, E. A. Edwards, 400,198. *Electric Lighting System*, W. L. Horne, 400,214. *Arc Lamp*, W. H. Miller, 400,352. *Incandescent Electric Lamp*, E. Weston, 400,378, March 26. *Device for Supporting Electric Lamps*, A. T. Moore, Jr., and H. A. Fitch, 400,473. *Electric Arc Lamp*, S. E. Nutting, 400,476. *Electric Lamp Attachment for Gas Fixtures*, E. F. Gennert, 400,-658. *Arc Lamp*, G. M. Lane, 400,692, April 2. *Manufacture of Incandescent Lamp Filaments*, T. D. Bottome, 401,120. *Device for Supporting and Operating Electric Lights*, C. W. Russell and J. I. Drake, 401,304, April 9. *Combined Lamp Shade or Reflector and Guard*, C. A. Cooley, 401,416. *Electric Lantern*, C. W. Cox and T. E. Van Dyke, 401,417. *Incandescent Lamp*, H. Lemp and M. J. Wightman, 401,444. *System of Electric Lighting*, T. A. Edison, 401,486. *Wiring Structures for Electric Lighting*, E. H. Johnson and E. T. Greenfield, 401,498. *Cut-Out for Incandescent Electric Lamps*, E. R. Whitney, 401,527. *Method of Exhausting Electric Lamp Bulbs*, J. W. Packard, 401,580. *Manufacture of Carbon Filaments*, E. P. Thompson, 401,-606. *Manufacture of Incandescing Carbon Filaments*, same, 401,607. *Incandescing Electric Lamp*, T. A. Edison, 401,646, April 16.

Measurement:—*Apparatus for Determining Electro or Magnetic Forces*, A. Gipperich, 400,661. *Art of Determining the Value of Electric, Magnetic, or Electro-Magnetic Forces by Weight*, same, 400,662. *Apparatus for Determining the Value of Electro-Magnetic Forces by Weight*, same, 400,663, April 2. *Standard Tangent Galvanometer*, E. Weston, 400,980. *Electric Meter*, A. H. Manwaren, 401,191; W. F. Smith, 401,226, April 9. *Process of Determining the Center of Attraction in Polarized Bodies*, A. Gipperich, 401,428. *Electrical Measurement Apparatus*, A. C. White, 401,617, April 16.

Medical and Surgical:—*Hinge-Joint for Electric Belts*, N. Warrell, 399,954, March 19. *Electro-Medical Apparatus*, J. J. Lewin, 401,041, April 9. *Therapeutic Attachment for Galvanic Batteries*, C. V. Osborn, 401,366. *Electro-Therapeutic Spectacles*, C. Brust, 401,682, April 16.

Metallurgical:—*Ore Separator*, T. A. Edison, 400,317, March 26. *Process of Reducing Aluminium from its Fluoride Salts by Electrolysis*, C. M. Hall, 400,664. *Manufacture of Aluminium*, same, 400,665. *Process of Electrolyzing Crude Salts of Aluminium*, same, 400,666. *Process of Electrolyzing Fused Salts of Aluminium*, same, 400,667. *Magnetic Separator*, G. Conkling, 400,746 and 400,747. *Process of Reducing Aluminium by Electrolysis*, C. M. Hall, 400,766, April 2. *Ore-Crusher and Metal Separator*, J. C. Wiswell, 400,-988, April 9. *Process of Treating Magnetic Iron Core*, G. Conkling, 401,414. *Magnetic Separator*, same, 401,415. *Magnetic Ore-Separator*, C. C. Coats, 401,688, April 16.

Metal Working:—*Process of Hardening Steel*, F. Sedgwick, 400,366, March 26. *Process of Electric Welding*, C. L. Coffin, 401,630. *Method of Tempering Spiral Springs*, F. Sedgwick, 401,721, April 16.

Miscellaneous:—*Electrically-Controlled Hydraulic Elevator*, C. Whittier, 399,716. *Electric Blast-Blower*, H. H. Blades, 399,822, March 19. *Automatic Grounding Device*, E. A. Sperry, 400,264. *Time-Recorder*, H. R. Adams, 400,-283, March 26. *Lightning Arrester*, M. D. Law, 400,463. *Lightning Rod and Coupling*, S. R. Lawshe, 400,464. *Phonograph*, C. Batchelor, 400,629. *Phonograph Recorder and Reproducer*, T. A. Edison, 400,646. *Phonograph*, same, 400,647. *Phonogram Blank*, same, 400,648. *Method of Making Phonogram Blanks*, same, 400,649 and 400,650. *Vacuum Pump*, J. T. Hambay, 400,668. *Safety Device for Electric Circuits*, W. J. Hammer, 400,669. *Method of Regulating Electric Currents*, J. W. Balet, 400,726. *Electric Switch*, S. Bergmann, 400,732. *Switch for Electric Circuits*, S. Bergmann, 400,733. *Spark-Coil*, F. H. Root, 400,795. *Switch Device for Electric Currents*, J. A. Turner, 400,808. *Electric Condenser*, W. Marshall, 400,866, April 2. *Electric Circuit-Testing Device*, M. Robinson, 400,951. *Induction-Coil and Self-Inductive Apparatus*, E. Thomson, 400,972. *Electric Heating Apparatus*, H. F. Watts, 400,978. *Circuit-Connecting Device*, J. C. Reilly, 401,067. *Lightning-Arrester*, E. Thomson, 401,085. *Lightning Conductor for Wire Fences*, F. E. Wood, 401,095. *Armature for Electro-Magnets*, J. Geary, 401,152. *Static Induction Machine*, H. Glaser, 401,156. *Electric Valve Controller*, W. E. Norris, 401,200. *Switch or Circuit-Changer*, W. W. Griscom, 401,270, April 9. *Electric-Wire Nail*, C. A. Gildemeyer, 401,343. *Attachment for Electro-Magnetic Thermoscopes*, H. J. Haight, 401,348. *Rheostat*, N. Bernardos, 401,405. *Register*, H. S. Ross, 401,518. *Indicating Device for Charging Furnaces*, E. Walsh, Jr., 401,521. *Valve-Actuating Apparatus*, J. W. Packard, 401,582, April 16.

Railways and Appliances:—*Electric Railway Switch*, E. Blake, 399,732. *Friction-Gear for Electric Motors*, C. J. Van Depoele, 399,950, March 19. *Electric Railway Plow*, E. M. Bentley, 400,038. *Electric Railway Contact*, same, 400,179. *Electric Railway Plow*, same, 400,180. *Fault Detector for Electric Railways*, same 400,182. *Friction-Gear for Electric Motors*, C. J. Van Depoele, 400,274. *Pneumatic Flexible-Slot Conduit for Electric Railway Conductors*, same, 400,375, March 26. *Electric Railway Signaling* W. H. Waddell, 400,525. *Trolley for Electrical Railways*, D. A. Ainslie, 400,724. *Trolley for Electric Railways*, same, 400,725. *Electric Car*, G. H. Condict and V. Angerer, 400,830. *Railway Signal*, S. T. Street, 400,880, April 2. *Current-Collecting Device for Electric Railways*, R. M. Hunter, 400,916. *Electric Railway*, R. Lundell, 400,936; S. H. Short, 401,221. *Apparatus for the Application of Electricity to Propel Vehicles*, F. Wynne, 401,322, April 9. *Electric Railway-Track Alarm*, T. Taylor, 401,472. *Electric Heating Apparatus for Railway Systems*, M. W. Dewey, 401,482. *Underground Conduit for Electrical Railways*, F. H. Reed, 401,515. *Electric-Alarm Advance Car*, H. Riesenberg, 401,591. *System of Electric Locomotion*, F. Wheeler, 401,616. *Railway Track Instrument*, G. C. Steenbergh, 401,664, April 16.

Secondary Batteries:—*Secondary Battery*, I. Kitsee, 400,226; R. M. Hunter, 400,404, March 26; W. W. Griscom, 400,842, April 2; W. Main, 401,289 and 401,-290. *Process of Preparing Electrodes for Secondary Batteries*, same, 401,-291, April 9. *Automatic Cut-Out for Secondary Batteries*, S. C. C. Currie, 401,332. *Secondary Battery*, J. S. Sellon, 401,466, April 16.

Telegraphs:—*Telegraphic Transmitter*, R. C. Stone (deceased), 400,141, March 26. *Harmonic Telegraphy*, F. Van Rysselberghe, 400,523, April 2. *Telegraph Apparatus for Ships*, J. B. Willis, 400,985, April 9. *Telegraphy*, P. B. Delany, 401,384, April 16.

Telephones and Apparatus:—*Telephone Transmitter*, C. A. Hitchcock 399,666, March 19. *Telephone*, N. B. Ginochio, 400,325 and 400,326. *Arm-Support for Telephones*, C. R. Tuttle, 400,520. *Telephone-Transmitter*, W. J. Morton, 400,591, April 2. *Telephone Support*, P. E. Hall, 400,911. *Spring-Jack Switch*, H. B. Thayer, 400,969. *Mechanical Telephone*, G. Thomas, 401,227, April 9.

EXPIRING PATENTS.

Patents relating to Electricity which become Public Property in May, 1889.

Reported for the ELECTRICAL ENGINEER, *by* F. B. Brock, *Patent Attorney* 639 *F street, Washington, D. C.*

Clock, W. M. Davis, 176,740. *Lightning-Rod*, S. Bradley, 176,769. *Conductor*, E. A. Hill, 176,784. *Lightning Rod*, L. D. Vermilya, 176,820. *Conductor*, F. S. Mead, 176,978. *Battery*, Brunelle & Mohr, 177,056. *Regulator*, E. Boyden, 177,058. *Thermostat*, J. H. Guest, 177,116. *Battery*, I. L. Pulvermacher, 177,273. Three patents on *Therapeutic Body Wear*, I. L. Pulvermacher, 177,274, 177,275, 177,276. *Conductor*, S. M. Barbour, 177,318. *Motor*, A. Shedlock, 177,359. *Gas Lighter*, A. L. Bogart, 177,459. *Printing Telegraph*, C. A. Randall, 177,661. *Recorder*, H. Whittemore, 177,671. *Burglar Alarm*, H. M. Reis, 177,750. *Key*, C. W. Lewis, 177,856. *Annunciator*, Axthelm & Pease, 177,918. Three patents, *Duplex Telegraphs*, T. A. Edison, 178,221, 178,222, 178,223. *Battery*, R. Einbigler, 177,996. *Regulator*, W. H. Gerrish, 178,138. *Battery*, J. E. Watson, 178,215. *Annunciator*, A. S. Wetmore, 178,216.

[Drawings and specifications of any patent will be furnished by Mr. Brock at cost, 15 cents each.]

THE

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VOL. VIII. NEW YORK, JUNE, 1889. No. 90.

THEN AND NOW.

THE little old yellow building at 21 Wall street has just been swept away by the march of improvement. There has scarcely been a time within the past forty years when the premises have not been occupied, wholly or in part, as a telegraph office. The writer well remembers visiting the place for the first time, just thirty years ago, when he was filled with amazement at the magnitude of the metropolitan main office, containing no less than thirty-one sets of instruments ; something more wonderful even than the celebrated " big pole " in Albany supporting forty-two wires. Probably this was then the most extensive telegraph office in the United States. Two of the old habitues, at least, have been dealt with not unkindly by Father Time—Myers, the care-taker of the receiving-room at 195 Broadway, who looks much as he used to, perched on a high stool in the front basement at " old 21 " deciphering from the slowly moving tape the hieroglyphics of the nautical practitioner at Sandy Hook ; and good old Finnegan, the " grinder," perhaps the most widely known person in the service. About 1861 the headquarters were removed to 145 Broadway, and in 1875 to the present building at 195 Broadway, which was designed to be capacious enough to serve for all time to come, but is already most uncomfortably crowded. The halcyon days of "old 21" were in truth the days of small things in the electrical way. What if the rate of progress since then should continue for the next thirty years?

THE NEW CAPITAL PUNISHMENT.

THE description given out of the apparatus to be used in this state under the law requiring executions in future to be by electricity (the first sentence under this law was pronounced to-day) raises the question whether the makers of that law and the persons who have devised the means for carrying it out are in strict accord. The law was undoubtedly enacted because, with the control now attained over electricity, it was thought that a criminal's death might be brought about instantaneously, and with no possibility of such horrors as come with broken ropes and the other mismanagement so often characteristic of hangings. Every now and then a workman touches a "live" wire, and dies with the touch. It was natural, therefore, to look to electricity as the best means of putting condemned criminals to death. But is it certain that the framers of this law intended that the victim should be seated in a formidable-looking chair, have his feet encased in shoes which contain damp sponges, have another sponge placed on his head, and his head clamped down with metallic bands—all this to be gone through with as the preparation for the death stroke? Was it not believed when the law was passed that the victim would die with the touch of a wire or a knob, and was not the absence of terror-giving paraphernalia and preparation one of the arguments in favor of the new means of death? The first executions in the electric chair will doubtless be very interesting to the scientists who have devised it; but will it not be found that M. de Paris can make better time with his guillotine than these modern electricians with their present system of applying the fluid?—*New York Evening Post*, May 14, 1889.

If the inside history of the electrical execution statute of the state of New York, and the subsequent proceedings thereunder, shall be given to the world, as we hope they will be, we venture to predict that the righteous wrath of all honest and humane people will fall heavily upon the heads of the philanthropists who have permitted themselves to be used in furtherance of this iniquitous scheme, which bears the ear-marks of having been devised solely in furtherance of petty personal ambitions and grudges.

The promoters of the enactment were wise in their generation when they embodied in it the provision precluding the publication of the details of the attempts at execution by electricity. Every reputable electrician understands perfectly well the vital necessity of keeping all knowledge of the matter from the public.

We are gratified to see that the *Evening Post* is at last beginning to entertain a suspicion that it has permitted its columns to be used in aid of the exploitation of a most ghastly imposition on the people of the State. In time it may come to understand that the formidable paraphernalia to which it properly takes exception are required for no better reason than that a particular form of commercial apparatus may be prejudiced by being employed to do a work for which it is in no wise adapted.

"WEARING TO THE CONSCIENCE."

IN his argument for Edison in the incandescent lamp case in the United States Court, at Pittsburgh, Mr. Lowrey attempted to discredit the evidence of Mr. Pope, who was one of the complainant's expert witnesses, in respect to a certain letter which he acknowledged having written to a friend in England, about the 1st of February, 1879, expressing in somewhat emphatic language his skepticism as to the success of the plan of electric lighting then being exploited by Mr. Edison, which criticism, as he testified, had especial reference to the platinum lamp and thermal regulator, which afterwards proved a failure and were abandoned. Mr. Lowrey said :—

It was concerning the thermostatic regulator. The letter of Pope in which he had said "Don't take any stock in this thing ; the system is nothing, it is of no account," was dated February 1, 1879. The fall in gas stock which he attributed to Mr. Edison's agency by means of *a system of lighting by incandescent platinum and a peculiar plan of lamp called a thermostatic regulator*, took

place in November 1878; and *your Honors will be interested to learn now that the thermal regulator lamp was patented and known to the world only April* 22, 1879. That is again one of those instances of sight behind so much better than sight before. Mr. Pope is *now* able to remember that on February 1, 1879, he denounced a particular kind of lamp, and that in November, 1878, the fall in gas stock was because of the inefficiency of a certain kind of lamp. *That lamp did not appear and was not known to the world until April* 22, 1879! You see there are very serious and strong exigencies in this case. Denials are called for that must be very wearing to the conscience. I trust that I have made it clear that the intimation which produced the excitement in gas shares, and which I take merely as an indication of what was the general public and scientific opinion as to the state of art, had reference not to a thermal regulator, not to any system, for *at that time Mr. Edison had not announced to anybody any system*; he probably had not at the earliest portion of the time formulated it to himself. He had simply felt it, with his genius. It was a system and plan for subdividing lights. When it was said that this man of international reputation had said that he believed he could do it, up rose the other scientific men and said "It cannot be done; we will prove it by figures," and down went the gas stock, proving by figures that the public believed that what he said he would do, he probably would do.

A case which requires to be supported by direct misrepresentations, must surely be *in extremis*. In reply to Mr. Lowrey's aspersions upon the testimony of Mr. Pope, it is only necessary to quote the following account, which appeared in the *Scientific American* of November 2, 1878, of the identical invention which Mr. Lowrey solemnly assured the court, only became known to the world so late as April 22, 1879.

But what is Mr. Edison's discovery? A few words will suffice to give an idea of it. *It is based on the well-known fact that a wire may be heated by an electric current*, the basis of many attempts to accomplish what Mr. Edison claims to have done. The reader may have seen the gas jets of the dome of the Capitol at Washington, lighted by similar means. Over each burner is placed a coil of *platinum wire*, which, when heated by the electric current, ignited the gas. Mr. Edison *uses the coil itself as the source of light, the current sent through it being strong enough to make the coil white hot, or self-luminous.* The difficulty to be overcome at this point was the liability of the wire to fuse and spoil the light; a difficulty which Mr. Edison claims to have obviated by the introduction of *a simple device which, by the expansion of a small bar the instant the coil approaches the fusing point of platinum, interposes a check to the flow of the current through the coil.* This automatic arrangement, in connection with an auxiliary resistance coil, secures, it is said, an even flow of electricity through the coil, and consequently a steady glow of pure light. If this is done economically it is obvious that a marked advance has been made in artificial illumination.

Other descriptions, in which most if not all the details of Mr. Edison's "great discovery" were set forth, were telegraphed to the London *Times* and the London *Daily News* by their New York correspondents in November and December, 1878.

Did not the total abandonment of the whole scheme of platinum lamps and thermal regulators show that Mr. Pope was right, and did not those who followed his advice and took no stock in it fare better than most of those who did?

Copper at 12 cents is better than at 16 cents for electrical industries as well as for manufacturers and consumers of the endless variety of metal goods. But why not 8 or 9 cents, as it is in London, since the copper mine people say that the cost of production is between 6 and 7 cents? Now that the incubus of the French "corner" has been removed, and a large part of the factitious price has dropped off, it is worth while to keep in mind that several cents of factitious value still remain in the price on this side of the Atlantic. The tariff of 4 cents a pound was a powerful ally of the late combination; and so long as it exists it will be a temptation to American mine owners and a menace, if not an actual oppression, to the public. At present it is an oppression, keeping the American price about four cents above the European price, notwithstanding the enormous surplus stock existing. The duty on copper is a conspicuous instance of the economic folly of our existing tariff system.

The Annual Meeting of the American Institute of Electrical Engineers was a success in every respect, and continues worthily the record of five years of growth and of improvement in the quality of membership and of work. The papers read at the general meeting of May 22 were of such obvious interest and excellence as to require no words of commendation to direct attention to them. We regret that our space does not permit printing the entire series in this issue of The Electrical Engineer. Those omitted will appear later. In respect to the paper on "The Inherent Defects of Lead Secondary Batteries," Dr. Duncan remarks—"This paper must be regarded more as a preliminary account of experiments which are still in progress than a finished description of them, and the few deductions which we have made may be modified by our subsequent work." The election of Professor Thomson to the presidency will receive the hearty approval of all electrical engineers in and out of the Institute.

The suppression of the telegraphic quotation service by the New York Stock Exchange, and its announced purpose, for the future, to return to the antiquated method of an army of boys, must not be taken too seriously. It is quite too funny on the part of such clever and wide-awake men as the members of the Stock Exchange to tell the public that they will have no more "tickers" and will henceforth rely upon "pushing the pad" for the distribution of quotations, and that they sacrifice their convenience for the purpose of killing off the wicked "bucket shops," all in the interest of public morals. As we go to press the truth of the matter begins to appear, and it seems likely that the Gold and Stock Telegraph Co., with the Commercial Telegram Co. under its sheltering wing, will in a few days be "ticking" away again livelier than ever under the stimulating influence of a large increase of rates for the service.

By reason of the great importance of the Westinghouse-Edison incandescent lamp suit, which was heard at Pittsburgh a few days since before Justices Bradley and McKennan, we arranged to secure a stenographic report of the argument on both sides, designing to print them in full in the Electrical Engineer, as a matter of record, as well as of immediate interest to all. The great length of the proceedings, filling, as they do, nearly 500 pages of type-written copy, renders this an impossibility, and we must, therefore, ask our readers to content themselves with the carefully prepared and very full abstract which we present in another part of this issue, and which will well repay a careful perusal.

ARTICLES.

ON MODERN VIEWS WITH RESPECT TO ELECTRIC CURRENTS.[1]

BY PROFESSOR H. A. ROWLAND.

As, a short time since, I stood in a library of physical books and glanced around me at the works of the great masters in that subject, my mind wandered back to the time when the apparatus for a complete course of lectures on the subject of electricity consisted of a piece of amber and a few light bodies to be attracted by it. From that time until now, when we stand in a magnificent laboratory with elaborate and costly apparatus in great part devoted to its study, how greatly has the world changed and how our science of electricity has expanded both in theory and practice until, in the one case, it threatens to include within itself nearly the whole of physics, and in the other to make this the age of electricity.

Were I to trace the history of the views of physicists with respect to electric currents it would include the whole history of electricity. The date when the conception of an electric current was possible was that when Stephen Gray, about 170 years ago, first divided bodies into conductors and non-conductors, and showed that the first possessed the property of transmitting electric attractions to a distance. But it was only when the Leyden jar was discovered that the idea of a current became very definite. The notion that electricity was a subtle fluid which could flow along metal wires as water flows along a tube, was then prevalent, and, indeed, remains in force to-day among all except the leaders in scientific thought. It is not my intention to depreciate this notion, which has served and still serves a very important purpose in science. But, for many years, it has been recognized that it includes only a very small portion of the truth and that the mechanism by which energy is transmitted from one point of space to another by means of an electric current is a very complicated one.

Here, for instance, on the table before me are two rubber tubes filled with water, in one of which the water is in motion, in the other at rest. It is impossible, by any means now known to us, to find out, without moving the tubes, which one has the current of water flowing in it and which has the water at rest. Again, I have here two wires, alike in all respects, except that one has a current of electricity flowing in it and the other has not. But in this case, I have only to bring a magnetic needle near the two to find out in which one the current is flowing. On our ordinary senses the passage of the current has little effect; the air around it does not turn green or the wire change in appearance. But we only have to change our medium from air to one containing magnetic particles to perceive the commotion which the presence of a current may cause. Thus this other wire passes through the air near a large number of small suspended magnets, and, as I pass the current through it, every magnet is affected and tends to turn at right angles to the wire and even to move toward it and wrap itself around it. If we suppose the number of these magnets to become very great and their size small, or if we imagine a medium, every atom of which is a magnet, we see that no wire carrying a current of electricity can pass through it without creating the greatest commotion. Possibly this is a feeble picture of what takes place in a mass of iron near an electric current.

Again, coil the wire around a piece of glass, or, indeed, almost any transparent substance, and pass a strong current through the wire. With our naked eye alone we see no effect whatever, as the glass is apparently unaltered by the presence of the current; but, examined in the proper way, by means of polarized light, we see that the structure of the glass has been altered throughout in a manner which can only be explained by the rotation of something within the glass many millions of times every second.

Once more, bring a wire in which no current exists nearer and nearer to the one carrying the current, and we shall find that its motion in such a neighborhood causes or tends to cause an electric current in it. Or, if we move a large solid mass of metal in the neighborhood of such a current we find a peculiar resistance unfelt before, and if we force it into motion we shall perceive that it becomes warmer and warmer as if there was great friction in moving the metal through space.

Thus, by these tests, we find that the region around an electric current has very peculiar properties which it did not have before, and which, although stronger in the neighborhood of the current, still extend to indefinite distances in all directions, becoming weaker as the distances increase.

How great then the difference between a current of water and a current of electricity. The action of the former is confined to the interior of the tube, while that of the latter extends to great distances on all sides, the whole of space being agitated by the formation of an electric current in any part. To show this agitation, I have here two large frames with coils of wire around them. They hang face to face about 6 feet apart. Through one I discharge this Leyden jar, and immediately you see a spark at a break in the wire of the other coil, and yet there is no apparent connection between the two. I can carry the coils 50 feet or more apart, and, yet, by suitable means I can observe the disturbances due to the current in the first coil.

The question is forced upon us as to how this action takes place. How is it possible to transmit so much power to such a distance across apparently unoccupied space? According to our modern theories of physics there must be some medium engaged in this transmission. We know that it is not the air, because the same effects take place in a vacuum, and, therefore, we must fall back on that medium which transmits light and which we have named the ether. That medium which is supposed to extend unaltered throughout the whole of space, whose existence is very certain but whose properties we have yet but vaguely conceived.

I cannot, in the course of one short hour, give even an idea of the process by which the minds of physicists have been lead to this conclusion, or the means by which we have finally completely identified the ether which transmits light with the medium which transmits electrical and magnetic disturbances. The great genius who first identified the two is Maxwell, whose electro-magnetic theory of light is the centre around which much scientific thought is to-day revolving, and which we regard as one of the greatest steps by which we advance nearer to the understanding of matter and its laws. It is this great discovery of Maxwell which allows me, at the present time, to attempt to explain to you the wonderful events which happen everywhere in space when one establishes an electric current in any other portion.

In the first place, we discover that the disturbance does not take place in all portions of space at once, but proceeds outwards from the centre of the disturbance with a velocity exactly equal to the velocity of light. So that, when I touch these wires together so as to complete the circuit of yonder battery, I start a wave of etherial disturbance which passes outward with a velocity of 185,000 miles per second, thus reaching the sun in about eight minutes, and continuing to pass onwards forever or until it reaches the bounds of the universe. And, yet, none of our senses inform us of what has taken place unless we sharpen them by the use of suitable instruments. Thus, in the case of these two coils of wire, suspended near each other, which we have already used, when the wave from the primary disturbance reaches the second coil, we perceive the disturbance by means of the spark formed at the break

1. A lecture given at the College of the City of New York, May, 22, 1889, before the American Institute of Electrical Engineers.

in the coil. Should I move the coils further apart, the spark in the second coil would be somewhat delayed, but the distance of 185,000 miles would be necessary before this delay could amount to as much as one second. Hence the effects we observe on the earth take place so nearly instantaneously that the interval of time is very difficult to measure, amounting, in the present case, to only $\frac{1}{180,000,000}$th of a second.

It is impossible for me to prove the existence of this interval, but I can at least show you that waves have something to do with the action here observed. For instance, I have here two tuning forks mounted on sounding boxes and tuned to exact unison. I sound one and then stop its vibrations with my hand, instantly you hear that the other is in vibration, caused by the waves of sound in the air between the two. When, however, I destroy the unison by fixing this piece of wax on one of the forks, the action ceases.

Now, this combination of a coil of wire and a Leyden jar is a vibrating system for electricity and its time of vibration is about 10,000,000 times a second. This second system is the same as the first, and therefore its time of vibration is the same. You see how well the experiment works now because the two are in unison. But let me take away this second Leyden jar, thus destroying the unison, and you see that the sparks instantly cease. Replacing it, the sparks reappear. Adding another on one side and they disappear again, only to reappear when the system is made symmetrical by placing two on each side.

This experiment and that of the tuning forks have an exact analogy to one another. In each we have two vibrating systems connected by a medium capable of transmitting vibrations, and they both come under the head of what we know as sympathetic vibrations. In the one case, we have two mechanical tuning forks connected by the air; in the other, two pieces of apparatus, which we might call electrical tuning forks, connected by the luminiferous ether. The vibrations in one case can be seen by the eye or heard by the ear, but in the other case they can only be perceived when we destroy them by making them produce a spark. The fact that we are able to increase the effect by proper tuning demonstrates that vibrations are concerned in the phenomenon. This can, however, be separately demonstrated by examining the spark by means of a revolving mirror, when we find that it is made up of many successive sparks corresponding to the successive backward and forward movements of the current.

The fact of the oscillatory character of the Leyden jar discharge was first demonstrated by our own countryman, Henry, in 1832, but he pursued the subject only a short distance, and it remained for Sir William Thomson to give the mathematical theory and prove the laws according to which the phenomenon takes place.

Thus, in the case of a charged Leyden jar whose inner and outer coatings have been suddenly joined by a wire, the electricity flows back and forth along the wire until all the energy originally stored up in the jar has expended itself in heating the wire or the air where the spark takes place and in generating waves of disturbance in the ether which move outward into space with the velocity of light. These etherial waves we have demonstrated by letting them fall on this coil of wire and causing the electrical disturbance to manifest itself by electric sparks.

I have here another more powerful arrangement for producing electro-magnetic waves of very long wave length, each one being about 500 miles long. It consists of a coil within which is a bundle of iron wires. On passing a powerful alternating current through the coil, the iron wires are rapidly magnetized and demagnetized and send forth into space a system of electro-magnetic waves at the rate of 360 in a second.

Here, also, I have another piece of apparatus [a lamp] for sending out the same kind of electro-magnetic waves; on applying a match, we start it into action. But the last apparatus is tuned to so high a pitch that the waves are only $\frac{1}{50,000}$ inch long, and 55,000,000,000,000 are given out in one second. These short waves are known by the name of light and radiant heat, though the name radiation is more exact. Placing any body near the lamp so that the radiation can fall on it, we observe that when the body absorbs the rays it is heated by them; the well-known property of so-called radiant heat and light. Is it not possible for us to get some substance to absorb the *long* waves of disturbance, and so obtain a heating effect? I have here such a substance in the shape of a sheet of copper, which I fasten on the face of a thermopile, and I hold it where these waves are the strongest [near the coil while the alternating current is passing through it]. As I have anticipated, great heat is generated by their absorption, and soon the plate of copper becomes very warm, as we see by this thermometer, by feeling of it with the hand or even by the steam from water thrown upon it. In this experiment the copper has not touched the coil or the iron wire core, although if it did they are very much cooler than itself. The heat has been produced by the absorption of the waves in the same way as a blackened body absorbs the rays of shorter wave length from the lamp; and, in both cases, heat is the result.[1]

But in this experiment, as in the first one, the wave-like nature of the disturbance has not been proved experimentally. We have caused electric sparks, and have heated the copper plate across an interval of space, but have not in either of these cases proved experimentally the progressive nature of the disturbance.

For a ready means of experimenting on the waves, obtaining their wave length and showing their interferences, has hitherto been wanting. This deficiency has been recently overcome by Professor Hertz, of Carlsruhe, who has made a study of the action of the coil, and has shown us how to use it for experiments on the etherial waves whose existence had before been made certain by the mathematics of Maxwell.

I scarcely know how to present this subject to a non-technical audience and make it clear how a coil of wire with a break in it can be used to measure the velocity and wave length of etherial waves. However, I can but try. If the waves moved very slowly, we could readily measure the time the first coil took to affect the second, and show that this time was longer as the distance was greater. But it is absolutely inappreciable by any of our instruments, and another method must be found. To obtain the wave length Professor Hertz used several methods, but that by the formation of stationary waves is the most easily grasped. Mr. Ames holds in his hand one end of a spiral spring, which makes a very heavy and flexible rope. As he sends a wave down it, you see that it is reflected at the further end, and returns again to his hand. If, however, he send a succession of waves down the rope, the reflected waves interfere with the direct ones, and divide the rope into a succession of nodes and loops, which you now observe. So a series of sound waves, striking on a wall, form a system of stationary waves in front of the wall. With this in view, Professor Hertz established his apparatus in front of a reflecting wall, and observed the nodes and loops by the sparks produced in a ring of wire. It is impossible for me to repeat this experiment before you, as it is a very delicate one, and the sparks produced are almost microscopic. Indeed, I should have to erect an entirely different apparatus, as the waves from the one before me are nearly $\frac{1}{4}$ mile long, the time of vibration of the system being very great, that is, $\frac{1}{10,000,000}$th of a second. To produce shorter waves we must use apparatus tuned, as it were, to a higher pitch, in which the same principle is, however, employed, but the etherial waves are shorter, and thus several stationary waves can be contained in one room.

The testing coil is then moved to different portions of the room, and the nodes are indicated by the disappear-

1. The thermopile was connected with a delicate minor galvanometer, the deflections of which were shown on a screen.

ance of the sparks, and the loops by the greater brightness of them. The presence of stationary waves is thus proved, and their half wave length found from the distance from node to node, for stationary waves can always be considered as produced by the interference of two progressive waves advancing in opposite directions.

However interesting a further description of Professor Hertz's experiments may be, we have gone as far in that direction as our subject carries us; for we have demonstrated that the production of a current in a wire is accompanied by a disturbance in the surrounding space; and, although I have not experimentally demonstrated the etherial waves, yet I have proved the existence of electric oscillations in the coils of wire and the ether surrounding it.

Our mathematics has demonstrated, and experiments like those of Professor Hertz have confirmed the demonstration, that the wave disturbance in the ether is an actual fact.

The closing of a battery circuit, then, and the establishment of a current of electricity in a wire is a very different process from the formation of a current of water in a pipe, though, after the first shock, the laws of the flow of the two are very much alike. But even then the medium around the current of electricity has very strange properties, showing that it is accompanied by a disturbance throughout space. The wire is but the core of the disturbance, which latter extends indefinitely in all directions.

One of the strangest things about it is that we can calculate with perfect exactness the velocity of the wave propagation and the amount of the disturbance at every point and at any instant of time; but as yet we cannot conceive of the details of the mechanism which is concerned in the propagation of an electric current. In this respect our subject resembles all other branches of physics in the partial knowledge we have of it. We know that light is the undulation of the luminiferous ether, and yet the constitution of the latter is unknown. We know that the atoms of matter can vibrate with purer tones than the most perfect piano, and yet we cannot even conceive of their constitution. We know that the sun attracts the planets with a force whose law is known, and yet we fail to picture to ourselves the process by which it takes our earth within its grasp at the distance of many millions of miles and prevents it from departing forever from its life-giving rays. Science is full of this half knowledge, and the proper altitude of the mind is one of resignation toward that which it is impossible for us to know at present and of earnest striving to help in the advance of our science, which shall finally allow us to answer all these questions.

The electric current is an unsolved mystery, but we have made a very great advance in understanding it when we know that we must look outside of the wire at the disturbance in the medium before we can understand it. A view which Faraday dimly held fifty years ago, which was given in detail in the great work of Maxwell, published sixteen years since, and has been the guide to most of the work done in electricity for a very long time. A view which has wrought the greatest changes in the ideas which we have conceived with respect to all electrical phenomena.

So far we have considered the case of alternating electric current in a wire connecting the inner and outer coatings of a Leyden jar. The invention of the telephone, by which sound is carried from one point to another by means of electrical waves, has forced into prominence the subject of these waves. Furthermore, the use of alternating currents for electric lighting brings into play the same phenomenon. Here, again, the difference between a current of water and a current of electricity is very marked. A sound wave, traversing the water in the tube, produces a to and fro current of water at any given point. So, in the electrical vibration along a wire, the electricity moves to and fro along it in a manner somewhat similar to the water but with this difference:—the disturbance from the water motion is confined to the tube and the oscillation of the water is greatest in the centre of the tube, while, in the case of the electric current, the ether around the wire is disturbed and the oscillation of the current is greatest at the surface of the wire and least in its centre. The oscillations in the water take place in the tube without reference to the matter outside the tube, whereas the electric oscillations in the wire are entirely dependent on the surrounding space, and the velocity of the propagation is nearly independent of the nature of the wire, provided only that it is a good conductor.

We have then, in the case of electrical waves along a wire, a disturbance outside the wire and a current within it, and the equations of Maxwell allow us to calculate these with perfect accuracy and give all the laws with respect to them.

We thus find that the velocity of propagation of the waves along a wire, hung far away from other bodies and made of good conducting material, is that of light or 185,000 miles per second; but when it is hung near any conducting matter, like the earth, or inclosed in a cable and sunk into the sea, the velocity becomes much less. When hung in space, away from other bodies, it forms, as it were, the core of a system of waves in the ether, the amplitude of the disturbance becoming less and less as we move away from the wire. But the most curious fact is that the electric current penetrates only a short distance into the wire, being mostly confined to the surface, especially where the number of oscillations per second is very great.

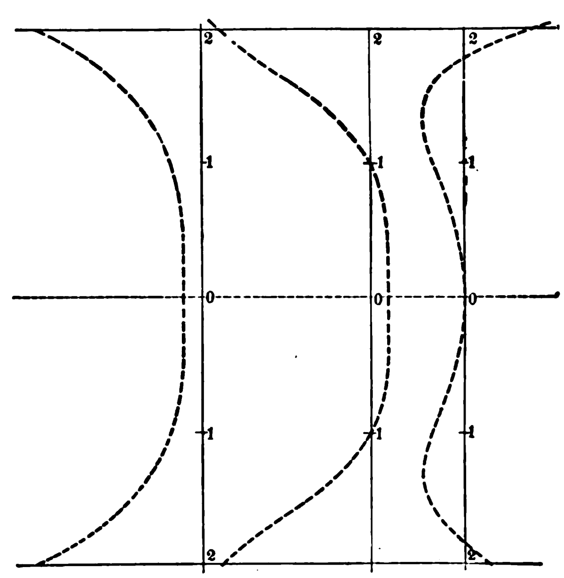


DIAGRAM 1.

The electrical waves at the surface of a conductor are thus, in some respects, very similar to the waves on the surface of water. The greatest motion in the latter case is at the surface while it diminishes as we pass downward and soon becomes inappreciable. Furthermore, the depth to which the disturbance penetrates into the water increases with increase of the length of the wave, being confined to very near the surface for very short waves. So the disturbance in the copper penetrates deeper as the waves and the time of oscillation are longer, and the disturbance is more nearly confined to the surface as the waves become shorter. I have recently made the complete calculation with respect to these waves, and have drawn some diagrams to illustrate the penetration of the alternating current into metal cylinders. The first diagram, represents the current at different depths in a copper cylinder 45 cm. diameter, or an iron one 14½ cm. diameter traversed by an alternating current with 200 reversals per second. The first and second curves show us the current at two different instants of time, and show us how the phase changes as we pass downward into the cylinder. By reference to the

third curve we see that it may even be in the opposite direction in the centre of the cylinder from what it is at the surface. The third curve gives us the amplitude of the current oscillations at different depths, irrespective of the phase, and it shows us that the current at the centre is only about 10 per cent. of that at the surface in this case. The second diagram shows us the distribution in the same cylinders when the number of reversals of the current is increased to 1,800 per second. Here we see that the disturbance is almost entirely confined to the surface, for at a depth of only 7 mm., the disturbance almost entirely vanishes.

There are very many practical applications of these theoretical results for electric currents. The most obvious one is to the case of conductors for the alternating currents used in producing the electric light. We find that when these are larger than about half an inch diameter they should be replaced by a number of conductors less than half an inch diameter, or by strips about a quarter of an inch thick, and of any convenient width. But this is a matter to be attended to by the electric light companies.

Professor Oliver J. Lodge, has recently, in the British Association, drawn attention to the application of these results to lightning rods. Almost since the time of Franklin, there have been those who advocated the making of lightning rods hollow, to increase the surface for a given amount of copper. We now know that these persons had no reason for their belief, as they simply drew the inference from the fact that electricity at best is on the surface. Neither were the advocates of the solid rods quite correct, for they reasoned from the fact that electricity in a state of steady flow, occupies the whole area of the conductor equally. The true theory, we now know, indicates that neither party was entirely correct and that the surface is a very important factor in the case of a current of electricity so sudden as that from a lightning discharge. But increase of surface can best be obtained by multiplying the number of conductors, rather than making them flat or hollow, and, at the same time, Maxwell's principle of enclosing the building within a cage can be carried out. Theory indicates that the current penetrates only one-tenth the distance into iron that it does into copper. As the iron has seven times the resistance of copper, we should need 70 times the surface of iron that we should of copper. Hence I prefer copper wire about a quarter of an inch diameter and nailed directly to the house without insulators, and passing down the four corners, around the eaves and over the roof, for giving protection from lightning in all cases where a metal roof and metal down spouts do not accomplish the same purpose.

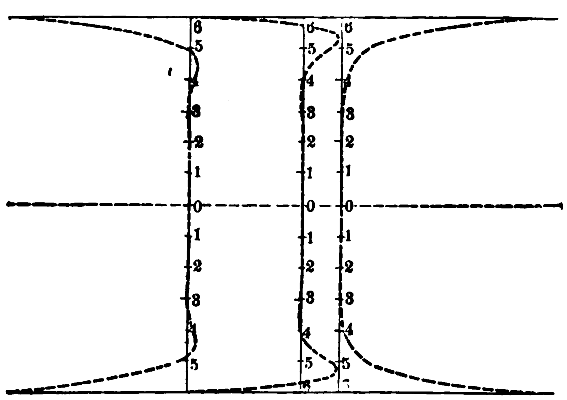


DIAGRAM 2.

Whether the discharge of lightning is oscillatory or not, does not enter into the question, provided it is only sufficiently sudden. I have recently solved the mathematical problem of the electric oscillations along a perfectly conducting wire joining two infinite and perfectly conducting planes parallel to each other, and find that there is no definite time of oscillation, but that the system is capable of vibrating in any time in which it is originally started. The case of lightning between a cloud of limited extent and the earth along a path through the air of great resistance is a very different problem. Both the cloud and the path of the electricity are poor conductors, which tends to lengthen the time. If I were called on to estimate as nearly as possible what took place in a flash of lightning, I would say that I did not believe that the discharge was always oscillating, but more often consisted of one or more streams of electricity at intervals of a small fraction of a second, each one continuing for not less than $\frac{1}{100,000}$ second. An oscillating current with 100,000 reversals per second would penetrate about $\frac{1}{80}$ inch into copper and $\frac{1}{800}$ inch into iron. The depth for copper would constitute a considerable proportion of a wire $\frac{1}{4}$ inch diameter; and, as there are other considerations to be taken into account, I believe it is scarcely worth while making tubes, or flat strips, for such small sizes.

It is almost impossible to draw proper conclusions from experiments on this subject in the laboratory, such as those of Professor Oliver J. Lodge. The time of oscillation of the current in most pieces of laboratory apparatus is so very small, being often the $\frac{1}{100,000,000}$th of a second, that entirely wrong inferences may be drawn from them. As the size of the apparatus increases the time of oscillation increases in the same proportion, and changes the whole aspect of the case. I have given $\frac{1}{100,000}$th of a second as the shortest time a lightning flash could probably occupy. I strongly suspect it is often much greater, and thus departs even further from the laboratory experiments of Professor Lodge, who has, however, done very much toward drawing attention to this matter and showing the importance of surface in this case. All shapes of the rod with equal surface are not, however, equally efficient. Thus, the inside surface of a tube does not count at all. Neither do the corrugations on a rod count for the full value of the surface they expose, for the current is not distributed uniformly over the surface; but I have recently proved that rapidly alternating currents are distributed over the surface of very good conductors in the same manner as electricity at rest would be distributed over them, so that the exterior angles and corners possess much more than their share of the current, and corrugations on the wire concentrate the current on the outer angles and diminish it in the hollows. Even a flat strip has more current on the edges than in the centre.

For these reasons, shape, as well as extent of surface, must be taken into account, and strips have not always an advantage over wires for quick discharges.

The fact that the lightning rod is not melted on being struck by lightning is not now considered as any proof that it has done its work properly. It must, as it were, seize upon the discharge, and offer it an easier passage to the earth than any other. Such sudden currents of electricity we have seen to obey very different laws from continuous ones, and their tendency to stick to a conductor and not fly off to other objects depends not only on having them of small resistance but also on having what we call the self-induction as small as possible. This latter can be diminished by having the lightning rod spread sideways as much as possible, either by rolling it into strips, or better, by making a network of rods over the roof with several connections to the earth at the corners, as I have before described.

Thus we see that the theory of lightning rods, which appeared so simple in the time of Franklin, is to-day a very complicated one, and requires for its solution a very complete knowledge of the dynamics of electric currents. In the light of our present knowledge the frequent failure of the old system of rods is no mystery, for I doubt if there are a hundred buildings in the country properly protected from lightning. With our modern advances, perfect protection might be guaranteed in all cases, if expense were no object.

So much for the rod itself, and now let us turn to other portions of the electrical system, for we have seen that, in any case, the conductor is only the core of a disturbance which extends to great distances on all sides. Were the clouds, the earth and the streak of heated air called the lightning flash all perfect conductors we could calculate the entire disturbance. It might then consist of a series of stationary waves between the two planes, extending indefinitely on all sides but with gradually decreasing amplitude as we pass away from the centre. The oscillation, once set up, would go on forever, as there would be no poor conductors to damp them. But when the clouds and the path of the lightning both have very great resistance, the energy is very soon converted into heat and the oscillations destroyed. I have given it as my opinion that this is generally the case and that the oscillations seldom take place, but I may be wrong, as there is little to guide me except guess work. If they take place, however, we have a ready explanation of what is sometimes called a back stroke of lighting. That is, a man at the other end of the cloud a mile or more distant from the lightning stroke sometimes receives a shock, or a new lightning flash may form at that point and kill him. This may be caused, according to our present theory, by the arrival of the waves of electrical disturbance which might themselves cause a slight shock or even overturn the equilibrium then existing and cause a new electric discharge.

We have now considered the case of oscillations of electricity in a few cases, and can turn to that of steady currents. The closing of an electric current sends etherial waves throughout space, but that after the first shock the current flows steadily without producing any more waves. However, the properties of the space around the wire have been permanently altered, as we have already seen. Let us now study these properties more in detail. I have before me a wire in which I can produce a powerful current of electricity and we have seen that the space around it has been so altered that a delicately suspended magnetic needle cannot remain quiet in all positions but stretches itself at right angles to the wire, the north pole tending to revolve around it in one direction and the south pole in the other. This is a very old experiment but we now regard it as evidence that the properties of the space around the wire have been altered rather than that the wire acts on the magnet from a distance.

Put, now, a plate of glass around the wire, the latter being vertical and the former with its plane horizontal, and pass a powerful current through the wire. On now sprinkling iron filings on the plate, they arrange themselves in circles around the wire and thus point out to us the celebrated lines of magnetic force of Faraday. Using two wires with currents in the same direction we get these other curves, and, testing the forces acting on the wire, we find that they are trying to move toward each other.

Again, pass the currents in the opposite directions and we get these other curves and the currents repel each other. If we assume that the lines of force are like rubber bands which tend to shorten in the direction of their length and repel each other sideways, Faraday and Maxwell have shown that all magnetic attraction and repulsions are explained. The property which the presence of the electric current has conferred on the luminiferous ether is then one by which it tends to shorten in one direction and spread out in the other two directions.

We have thus done away with action at a distance, and have accounted for magnetic attraction by a change in the intervening medium as Faraday partly did almost fifty years ago. For this change in the surrounding medium is as much a part of the electric current as anything that goes on within the wire.

To illustrate this tension along the lines of force, I have constructed this model which represents the section of a coil of wire with a bar of iron within it. The rubber bands represent the lines of force which pass around the coil and through the iron bar, as they have an easier passage through the iron than the air. As we draw the bar down and let it go, you see that it is drawn upward and oscillates around its position of equilibrium until friction brings it to rest. Here, again, I have a coil of wire with an iron bar within it with one end resting on the floor. As we pass the current and the lines of magnetic force form around the coil and pass through the iron, it is lifted upwards although it weighs 24 pounds and oscillates around its position of equilibrium exactly the same as though it were sustained by rubber bands as in the model. The rubber bands in this case are invisible to our eye but our mental vision pictures them to us as lines of magnetic force in the luminiferous ether drawing the bar upward by their contractile force. This contractile force is no small quantity as it may amount, in some cases, to one or even two hundred pounds to the square inch, and thus rivals the greatest pressure which we use in our steam engines.

Thus the luminiferous ether is, to-day, a much more important factor in science than the air we breathe. We are constantly surrounded by the two, and the presence of the air is manifest to us all; we feel it, we hear by its aid and we even see it, under favorable circumstances, and the velocity of its motion as well as the amount of moisture it carries, is a constant topic of conversation with mankind at large. The luminiferous ether, on the other hand, eludes all our senses and it is only with imagination, the eye of the mind, that its presence can be perceived. By its aid in conveying the vibrations we call light, we are enabled to see the world around us, and by its other motions which cause magnetism, the mariner steers his ship through the darkest night when the heavenly bodies are hid from view. When we speak in a telephone, the vibrations of the voice are carried forward to the distant point by waves in the luminiferous ether, there again to be resolved into the sound waves of the air. When we use the electric light to illuminate our streets, it is the luminiferous ether which conveys the energy along the wires as well as transmits it to our eye after it has assumed the form of light. We step upon an electric street car and feel it driven forward with the power of many horses, and again it is the luminiferous ether, whose immense force we have brought under our control and made to serve our purpose. No longer a feeble uncertain sort of medium but a mighty power, extending throughout all space and binding the whole universe together, so that it becomes a living unit in which no one portion can be changed without ultimately involving every other portion.

To this, ladies and gentlemen, we have been led by the study of electrical phenomena, and the ideas which I have set forth constitute the most modern views held by physicists with respect to electric currents.

ELECTRIC MOTOR REGULATION.[1]

BY FRANCIS B. CROCKER.

Although this subject is one of great scientific and practical interest, it has not been very frequently or very fully treated up to the present time. Of course, motor regulation is very similar to dynamo regulation, but it is by no means identical with it, and it deserves and requires separate treatment. I do not think it is much exaggeration to say that at the present time there is no subject more generally important to electrical engineers than motor regulation. Considering this fact, it is certainly remarkable that the literature of the subject is so limited. We find stray articles in electrical periodicals, rarely more than a description of one particular invention, and in electrical books, regulation is referred to incidentally in

1. Read before the American Institute of Electrical Engineers, May 22, 1889.

descriptions of various motors. There is, also, to be sure, usually one short chapter devoted to this subject, but it is apt to be either very general, merely mentioning a few regulating devices, or else, it is confined to the mathematical analysis of some one particular method.

Motor regulation is a subject which is somewhat confusing, and requires, therefore, accurate definition of the quantities and conditions which enter into it. One case is, at first sight, very similar to another, and yet more careful consideration will show, very likely, that it is exactly opposite. Take, for example, the two commonest and most important cases, viz: the constant potential and the constant current motors. The conditions of the two cases are precisely opposite and the solution of the problem is, naturally, entirely different. To maintain a motor at a constant speed with a variable load on a constant potential circuit, which is the case of the ordinary shunt motor on the regular 110 volt incandescent circuit, is a very easy problem; in fact, it solves itself. A simple shunt-wound motor will run at a practically constant speed on a constant potential circuit, even if the load varies from zero up to the full capacity of the motor. Now, this form of motor is exactly what we would use, even if we did not care to have it regulate. It is customary, to be sure, where very close regulation is required, to wind constant potential motors differentially, *i. e.*, with series as well as shunt coils, but this is not essential for ordinary work.

The case of the constant current motor, on the other hand, is as difficult as the first is easy. It seems as if it had to bear the burden of both. Neither a shunt-wound nor a series-wound nor a compound-wound motor can be used practically on a constant current circuit to maintain a constant speed with variable load. The ordinary series-wound motor, which is the natural and common form for the constant current motor, will race away when the load is taken off and increase in speed until it tears apart or strains the armature and ruins the machine. We require some special and very effective device to accomplish the regulation in this constant current case, and it seems to happen that almost every device that has been thought of has serious difficulties and complications. The ordinary, and what would seem to be the best solution of this problem is to vary the magnetic effect of the field upon the armature directly in proportion to variations in the load. This is effected by cutting out the field coils, and by other methods which will be described later. But there are serious difficulties with almost all these plans.

These two cases, which, as already stated, are the commonest and most important which occur, and yet which are so very different in almost every respect, give a general idea of what we have to deal with in motor regulation.

In order to fix and hold the rather numerous quantities and conditions that present themselves in connection with motor regulation a tabular statement of them is given below.

Table I.

ELECTRIC MOTOR REGULATION.

1. Hand regulation.
   Usually employed for varying the speed.
2. Automatic regulation.
   Usually employed to maintain constant speed, and is effected by
   Centrifugal governors.
   Dynamometric governors.
   Electro-magnetic devices.

PRINCIPAL METHODS OF MOTOR REGULATION.

1. Shunt winding. Figure 1.
2. Differential winding. Figure 2.
   Varying external resistance in series with
3. Armature.
4. Field. Figure 1.
5. Both armature and field.
   Varying internal resistance of
6. Armature.
7. Field by cutting out coils in series. Figure 3.
8. Field by cutting out coils in multiple arc. Figure 4.
9. Field by grouping coils in series or multiple arc.
10. Both armature and field. Figure 5.
    Varying shunt in multiple arc with
11. Armature.
12. Field.
13. Both armature and field. Figure 6.

14. Varying current in separately excited field.
15. Shunting field magnetism. Figure 7.
16. Short circuiting field magnetism. Figure 8.
    Varying commutation by
17. Shifting brushes. Figure 9.
18. Shifting commutator.
19. Shifting magnetic resultant.

20. Moving pole-pieces away from armature. Figure 10.
21. Moving armature away from pole-pieces. Figure 11.

Table II.

LIST OF POSSIBLE CASES WITH DIRECT CURRENTS.

P = Difference of potential in volts at terminals of motor.
C = Current in amperes supplied to motor.
S = Speed of armature in revolutions per minute.
L = Load or torque in lbs. at one foot radius.

Any of these four quantities may be either constant or variable, making the following combinations:—

Case.	Constant.	Variable.	Example.
1.	P	$C\ S\ L$	Series wound motor with variable load on const. pot. cir.
2.	$P\ S$	$C\ L$	Shunt or comp. wound motor with variable load on con. pot. cir.
3.	$P\ L$	$C\ S$	Shunt motor with con. load and var. field resist. on con. pot. cir.
4.	$P\ S\ L$	C	Not practical.
5.	$P\ C$	$S\ L$	Not likely to occur.
6.	$P\ C\ S$	L	Not practical.
7.	$P\ C\ L$	S	Not practical.
8.	$P\ C\ S\ L$		Shunt motor with constant load on constant potential circuit.
9.	C	$P\ S\ L$	Shunt motor with var. load on constant current circuit.
10.	$C\ S$	$P\ L$	Series motor with speed gov. and var. load on const. cur. circuit.
11.	$C\ L$	$P\ S$	Not likely to occur.
12.	$C\ S\ L$	P	Not practical.
13.	S	$P\ C\ L$	Motor with speed gov. and var. load on cir. of var. pot. and cur.
14.	$S\ L$	$P\ C$	Motor with const. load and speed gov. on cir. of var. pot. and cur.
15.	L	$P\ C\ S$	Mot'r with con. load without speed gov. on cir. of var. pot. and cur.
16.		$P\ C\ S\ L$	Mot'r with var. load without speed gov. on cir. of var. pot. and cur.

In table i., motor regulation is divided into hand regulation, which it happens, is almost always used for varying the speed of a motor, by a hand switch, figure 1, for example, and automatic regulation, which is almost always used to maintain a constant speed, and which is usually accomplished in one of the three following ways: first, by a centrifugal governor similar to that of the steam engine, operating a switch or other device (figure 3); secondly, by a dynamometric governor, *i. e.*, a mechanism through which the load or torque of the motor is transmitted, which may also operate a switch and vary the power of the field by the direct effect of changes in the load; thirdly,

by an electro-magnetic device, such as a solenoid, through which the current or a portion of it, is passed, which causes the core of the solenoid to move and operate a switch, in accordance with variations in the current (figure 9).

The table next gives the principal methods used to regulate motors. These consist of different arrangements and combinations of parts, to produce different effects or changes in the working of the motor, and they constitute the means which we have to employ to accomplish a certain object in motor regulation. Method 1, is simple shunt winding, which consists in exciting the field magnet with a circuit of comparatively high resistance in multiple arc with the armature (figure 1). This maintains a motor

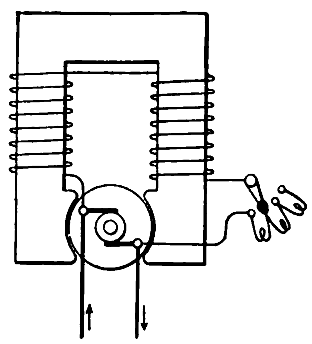


FIG. 1.—Shunt Motor with Variable Resistance in Field Circuit.

at constant speed with varying load on a constant potential circuit, and does this all by itself, as it were, without any trouble, as already pointed out. The reason for this is, that the field, being fed with a constant potential is therefore of constant strength, and a slight variation in speed of the armature, about five per cent., will vary the current in it from zero up to its full capacity, and, therefore, vary its power to an equal extent.

Method 2 is differential winding (figure 2), which is a refinement of the first, by which an almost absolutely constant speed, *i. e.*, within one or two per cent., may be practically maintained. This consists in winding a series coil of comparatively few turns upon the field magnets, in addition to the shunt-winding in the previous case, the series coil being wound in the opposite direction and opposed magnetically to the shunt coil. The effect of this is to slightly weaken the field magnetism as the load on

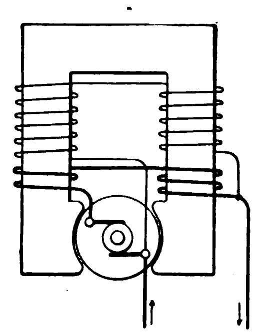


FIG. 2.—Differential Motor. Self-Regulating.

the armature, and consequently its current increases. This tends to increase the speed of the armature and counteract its tendency to slow down with increased load, thereby almost entirely eliminating even the small variation of five per cent. in speed which occurs in the ordinary shunt motor. The paradoxical fact that a shunt motor increases its speed with the weakening of the field, is well known, being due to the lowering of the counter-electromotive force, and consequent increase of current in the armature as the field magnetism is reduced in intensity.

In the next three methods the external resistance in series with the armature or field, or both, is varied. Method 3 would be very wasteful and is hardly allowable in good practice, because it is simply destroying the main current to put resistance in the armature circuit. Method 4, varying the resistance in the field circuit, is very much less objectionable and is very convenient and common (figure 3). This mode can be adopted with a very small loss of current, because the field current is only a small part of the total current used in the motor, and the loss of a portion of this small fraction is practically insignificant. Method 5, putting external resistance in series with both the armature and field, is open to same objection as case 3, since it throttles and destroys part of the main current.

The next five modes of regulation, 6, 7, 8, 9 and 10 are theoretically more economical than the preceding, because

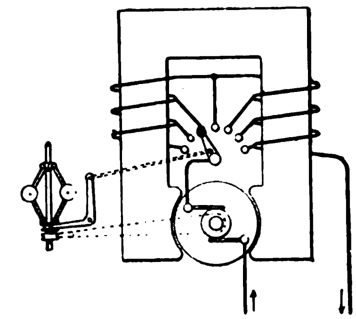


FIG. 3.—Series Motor with Switch for Cutting Out Coils in Series.

we vary the internal or useful resistance, instead of adding external or dead resistance. Method 6, in which the internal resistance of the armature is varied is very difficult to carry out in practice, simply because it is hard to get at and change the connections of the armature while it is revolving. One of the few ways devised to accomplish this, is to wind the armature with two or more circuits connected to a corresponding number of commutators, whereby one or more of these circuits may be used, thus varying the internal resistance and torque. This is clumsy and is practically little better than using two or more separate motors.

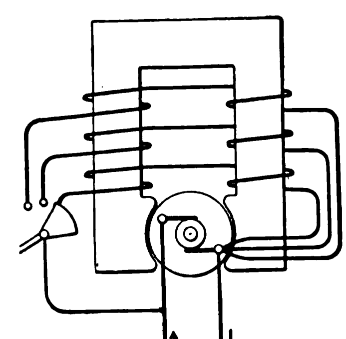


FIG. 4.—Shunt Motor with Switch for Cutting out Field Coils in Multiple Arc.

Method 7, cutting out the field coils in series, is a very simple and common plan. It is the ordinary way of regulating constant current or other series-wound motors. This method, or some modification of it, is the one according to which the constant current or "arc" motors of the Baxter, C. & C. and Excelsior companies, are constructed.

Method 8, of cutting out field coils in multiple arc, is shown in figure 4, and is especially applicable to shunt-wound motors. The different layers, for example, may be respectively connected to the contact points of a switch, and thrown into circuit successively, the innermost layer first, etc., thus obtaining the most economical result.

Method 9, of grouping the field coils in series or in multiple arc, produces very great variations in field resistance, and is a combination of the two preceding cases. Like them, it consists in winding the field with separate circuits which are connected to a switch. This is employed in street car motors to obtain great variations in resistance and power.

Method 10 is also merely a combination of two or more of the four preceding cases. A simple way of carrying it out is illustrated in figure 5, and consists in connecting the armature and field either in series or in multiple arc, by which a great variation in the total internal resistance of the machine is obtained.

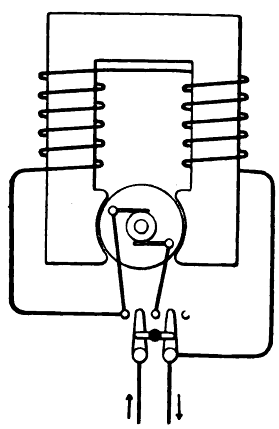


FIG. 5.—Motor with Switch for Throwing Armature and Field in Series or in Multiple Arc.

The next method, No. 11, is open to the same objection as No. 6, because when the armature is shunted the main current of the machine is affected. This is, however, less objectionable than dead resistance, because in most cases, it is better to divert the current than to destroy it.

Method 12, like methods 4 and 7, is a useful and common one, because in shunting the field we are merely handling a very small fraction of the total current.

Method 13, varying a shunt in multiple arc with both armature and field, is wasteful like No. 11. It was, however, the plan by which the first arc motors were regulated,

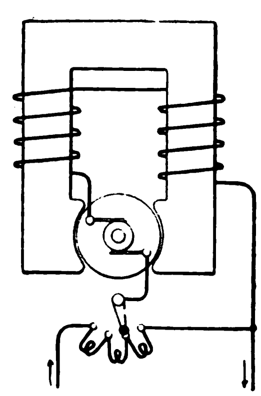


FIG. 6.—Series Motor on Variable Shunt.

a variable shunt being placed in the main circuit and the motor connected to the terminals of the shunt. The variations in the shunt, of course, throw more or less current through the motor, thereby varying its power as required (figure 6).

Method 14, varying the current in a separately excited field, is merely historical, as this class of motors has gone out of use. The plan, however, is a very effective one, because, of course, it is very easy to control the field current when it is produced by a separate source.

Method 15 is shown in figure 7, and consists in shunting the field magnetism, *i. e.*, diverting the lines of force from the armature through some other path. In the arrangement shown, there is a simple series wound motor with consequent pole field magnet, and if the coils exciting one magnetic circuit are short-circuited, it is evident that the magnetism produced by the other magnetic circuit, will be short-circuited or shunted by the former. The short-circuiting of the coils is effected by the variable shunt, as indicated.

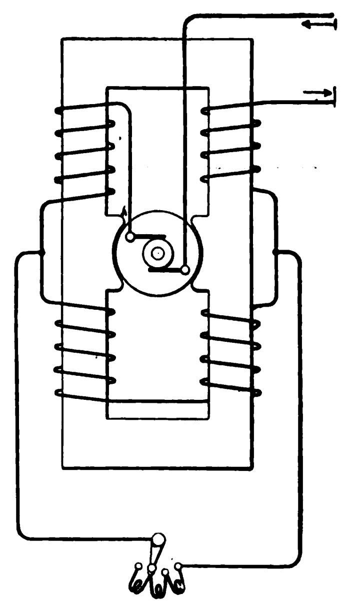


FIG. 7.—Series Motor with Variable Magnetic Shunt.

Method 16 is very similar to the preceding, and consists in short-circuiting the field magnetism and diverting it from the armature by a keeper, which may be moved towards or away from the pole-pieces by means of a screw or other contrivance.

We now come to methods 17, 18 and 19, in which the line of commutation is varied. The first is the well-known plan of shifting the brushes. This is very effective and easily carried out, and has, therefore, been used quite extensively; but it has the very serious and almost prohibitory objection that when the brushes are moved from the

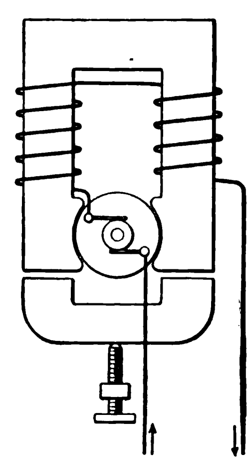


FIG. 8.—Series Motor with Variable Magnetic Short Circuit.

neutral point they spark very badly. This may be remedied to a slight extent by some heroic plan, like blowing out the spark produced. But, as sparking is one of the worst drawbacks of a motor, it hardly seems as if this method of regulation would be permanent. It may be said here, that certain methods of regulation may be all right for dynamos, which usually receive the constant care

of skilled men; but in motors, which generally get little or no care, the same method may not be allowable.

Method 18, shifting the commutator, is simply another way of doing the same thing.

Method 19, shifting the magnetic resultant or direction of lines of force in the armature, may be accomplished by two sets of pole-pieces, the relative magnetic strength of which is varied. This is also open to the same objection as shifting the brushes.

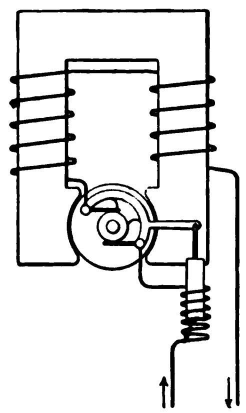


FIG. 9.—Series Motor with Automatic Device for Shifting Brushes.

Method 20, shown in figure 10, consisting in moving or separating the pole-pieces from the armature, has been used in the Diehl and other motors, but it is rather difficult to carry out mechanically, and introduces a hinge or joint in the magnetic circuit, which is, of course, very undesirable.

Method 21, moving the armature away from the pole-pieces, is very much easier to accomplish mechanically, and has a great many advantages as a means of regulation. Mr. S. S. Wheeler and myself have been working for some time on motors in which this method of regulation is employed and the results we have obtained have been very satisfactory, in fact, we found it to be extremely simple, effective and reliable.

The second table gives a list of the possible cases of motor regulation which may occur with direct or continuous currents. There are four supremely important quantities or conditions in connection with electric motor regulation—potential, current, speed and load—and it is with reference to one or more of these that practically all motors are designed, built, sold and used. Motors are always distinguished, both in science and in trade as constant potential or constant current motors ; constant or variable speed motors, and constant or variable load motors ; hence a classification of motors based upon the constancy or variability of these four factors is very convenient, and at the same time scientifically correct. The second table is made upon this plan, and in it the four quantities are represented by their initial letters, P, C, S and L, expressed respectively in volts, amperes, revolutions per minute, and torque in pounds, at one foot radius, these being the units ordinarily used, in practical as well as scientific work. We find that there are in all, 16 different cases, in the first four of which the potential is constant ; in the second four the potential and current are both constant, in the third four the current only is constant, and in the fourth four neither the current nor the potential is constant.

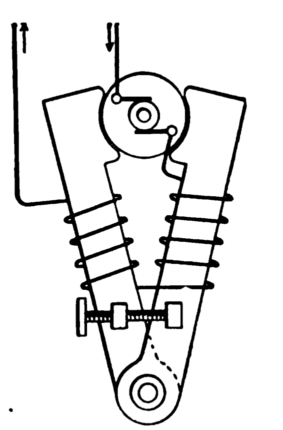


FIG. 10.—Series Motor with Device for Moving Pole Pieces Apart.

Case 1, in which the potential alone is constant is that of a series-wound motor, for example, with variable load on a constant potential circuit. Such a motor would rise in speed when the load was reduced and *vice versa*. It would not be at all self-regulating, in fact, it would tend to run at a very high speed with light load, and a very slow speed with a heavy load. It is possible to give various other examples, but one is sufficient in most cases. In this case, however, I may say that the ordinary street car motor, fed from a constant potential circuit, is also an example of case 1, the current being controlled by varying the external or internal resistance, according to one of the methods given in the first table.

Case 2 is that of the ordinary shunt or differential motor, with a variable load on a constant potential circuit. This is self-regulating and maintains a constant speed, as already stated, and is the commonest case of motor regulation met with. The current varies directly with the load.

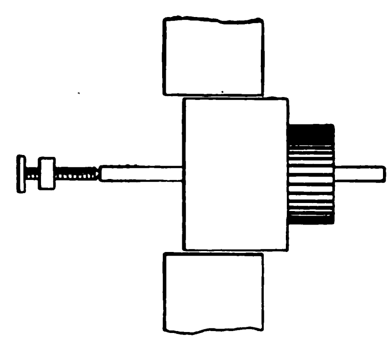


FIG. 11.—Series or Shunt Motor with Regulator for Moving Armature Out of Field.

Case 3 is that of the ordinary shunt motor with constant load, having a variable resistance in the field magnet. This case is shown in figure 1. Increasing resistance of field circuit would weaken field magnetism and motor would run faster and take more current, *i. e.*, current would vary directly with speed.

Case 4 is not a practical one, because, if potential, speed and load are constant, the current cannot be varied without wasting it, that is, any excess of current would be simply destroyed, which, of course, is not permissible.

Case 5 is not likely to occur, because potential and current would not be constant with a variable load and speed, but if it did occur, it would require that the speed and load should vary inversely.

Cases 6 and 7 are not practical for the same reason as given in case 4, because if potential, current and speed were constant the load could not be reduced without wasting electrical energy, and in case 7, the speed could not be varied without wasting energy.

Case 8 is that in which all four factors are constant, and is best illustrated by a shunt motor with constant load on a constant potential circuit, in which case the current and speed would also be constant.

Case 9 may be illustrated by a shunt motor with variable load on a constant current circuit. The speed would run up as the load reduced. A more common example is a series motor on constant current circuit, with switch for cutting out field coils, or, in short, a constant current motor with variable speed and load.

Case 10 is that of the regular constant current or "arc" motor with governor, such, for example, as the Baxter or "C. & C." motor. The ordinary form is a series motor with a centrifugal governor which operates a switch to cut in and out the field coils, as shown in figure 3. This is, next to the shunt and differentially wound motors, the most common and important case of motor regulation.

Case 11 is that of a constant current motor with constant load, and having a switch for varying field strength. The potential would rise directly with speed, but this case is not likely to occur.

Case 12 is not practical for the same reason as case 4.

The last four cases are those in which both potential and current vary. They are hardly practical cases, because electrical distribution is almost always either constant current or constant potential. It is, however, of course, possible to have cases where both may vary, and examples of each case are given.

Case 13 is one which does occur to a certain extent in practice, for example, if a so-called constant current circuit varies slightly, as they always do in practice, say from 9 to 10 amperes, then the current as well as the potential are variable, and this must be taken account of in the regulation.

In the experiments which I have already referred to, Mr. Wheeler and I have built a motor of the constant current type which will govern for wide variations in current as well as in load. This motor, for example, will not fall in speed, even though the current be reduced from 10 to 5 amperes, which is a great variation for this type of motor, as the field and armature being in series, the torque varies as the square of the current. This variation in current in the so-called constant current circuits is a much greater percentage than the variation in potential of so-called constant potential circuits, and amounts to from ½ to 1 ampere.

Having generally described the different cases of motor regulation, let us take up the mathematical relation of potential current, speed and load, which may be expressed quite simply.

Using the symbols P, C, S and L, as defined above, we have $P \times C$ as the total electrical energy supplied to motor in watts or $\frac{P\,C}{746}$ in horse-power. Calling commercial efficiency a, the actual mechanical horse-power developed by motor is $\frac{a\,P\,C}{746}$ expressed in electrical terms. The equivalent expression in mechanical terms is $\frac{2\,\pi\,S\,L}{33{,}000}$. Since the point at which load L is measured is one foot from centre of shaft and travels $2\,\pi$ feet per revolution, or $2\,\pi\,S$ feet per minute, this multiplied by the load and divided by 33,000, gives horse-power developed by motor.

Thus we have :—

$$\frac{a\,P\,C}{746} = \frac{2\,\pi\,S\,L}{33{,}000} = \text{horse-power of motor.}$$

or

$$P\,C = \frac{746 \times 2\,\pi\,S\,L}{33{,}000 \times a} = \frac{S\,L}{7.04 \times a}$$

For convenience we may write $P\,C = \frac{S\,L}{7a}$ with an error of about one-half of one per cent.

If the efficiency a, of motor is 85.2 per cent., the denominator $7.04a$ becomes 6 exactly, and we have $P\,C = \frac{S\,L}{6}$, and if the efficiency is 75.8 per cent., we have $P\,C = \frac{S\,L}{5}$. The former is as high and the latter is as low an efficiency as is ordinarily met with in practical work, therefore these are the limiting values.

The equation $P\,C = \frac{S\,L}{7.04a}$ or one of the three simplified forms just given, may be advantageously used for solving problems in motor regulation. If we know any four of the quantities we may, of course, find the fifth by simply solving the equation with respect to it. It is also evident that if any three of the quantities are constant then the other two will vary directly or inversely with each other, depending upon their position in the equation. This is the ordinary case we have to deal with in regulation. Usually speed is required to be constant, either potential or current is maintained constant, and efficiency should be practically constant down to very small loads; thus we have either current or potential varying directly with load. The efficiency is rather a confusing element in motor regulation. For this reason it was not introduced as a fifth quantity in the second table, as it would have complicated it and made a great many more possible cases. The efficiency should be high (close to 100 per cent.), and as nearly as possible constant; therefore it would not affect the figures much.

If the load or speed is zero, or very low, the potential or current should be correspondingly reduced and the efficiency would remain constant. This is the condition for perfect regulation. Practically it always takes some current to overcome friction, &c., even when load is zero, in which case efficiency is zero, but this current should be very small.

The equation $P\,C = \frac{S\,L}{7.04a}$ applied to the cases marked "not practical" in second table, shows in case 4 for example, that if $P\,C$ and L are constant, efficiency a decreases directly with reduction in speed. This is not allowable. The same is true of the other cases that it is not proper to vary $P\,C$ or L simply at the expense of efficiency, or in other words waste energy to obtain regulation.

Having now given the general points of the subject of motor regulation, we will proceed to consider the forms of motors which are now being used.

First, and most important, we have the regular shunt motor for constant potential circuits, which has already been referred to several times. Thousands of this type of motor are in use and give very satisfactory results. A properly designed motor of this kind will regulate within five per cent., which is near enough for most purposes. It has no regulating mechanism or complicated circuits to get out of order, and it may be called the ideal self-regulating machine. The next important form is the differentially wound motor, which is even more perfect in closeness of regulation. Theoretically it might be made almost absolutely constant in speed, practically the speed varies about two per cent. These are the figures given me by the company who manufacture these machines in the largest quantity and of the most excellent workmanship. Silvanus Thompson gives an example of one of these machines, which only varied 1½ per cent. in speed, with a variation from 1.1 to 11.14 h. p.

The rule for winding differential motors is that the number of turns in the shunt divided by the number of turns in the series coil, are equal to the resistance of the shunt divided by the sum of the resistances of the armature and the series coil. On this side of the Atlantic this is called "Sprague's law of winding;" on the other side it is called "Ayrton and Perry's rule for winding." The slight variation in speed which does occur is due to the heating of the coils and other slight disturbances. The shunt coil varies slightly in resistance by heat, therefore the series coil should have a few less turns than the rule requires. The heating of the shunt coil weakens the current in it, and consequently the field magnetism, thus increasing the speed of the machine; therefore the motor runs faster after it has been running for some time. The proper way is, of course, to consider the true speed to be that which the motor has in steady running. At first, some trouble was experienced in this type of machine on account of short-

circuiting between the series and shunt coils, but this has been overcome by more perfect insulation.

The shunt or differentially-wound machines may be varied in speed by putting resistance in the field circuit, as shown in figure 1. This may, of course, be done automatically, or by hand, usually the latter.

The next important type of machine is the constant current motor. As already stated, this is merely a series-wound machine, with switch for cutting in and out the field coils, the latter being operated by an automatic centrifugal governor, as indicated in figure 3, or by hand. Various modifications of this type have been made; for example, a reversed coil having a variable resistance in circuit with it, may be used in multiple arc with regular series field winding. If this resistance is very high, the reversed coil has little or no effect; if this resistance is made very low, it will rob the main coil of its current and also neutralize its effect, thereby greatly reducing the strength of the field magnet.

Constant current machines with regulator are now in great demand for arc circuits, in fact, it is not practical or safe to use a motor on an arc circuit without a regulator. The differential winding of constant current motors to maintain constant speed is not practicable. The solution of it requires, either that the efficiency should be very low, or that storage batteries be used in combination with the winding to maintain a constant difference of potential. Any such plan as this is, of course, very objectionable.

The three types just given are really about the only continuous current motors used to any extent in practice, and it seems that there is at present no demand for any other type.

Nothing has been said of the regulation of alternating current motors, because it is a radically different subject, and moreover alternating current motors tend to run synchronously, maintaining a constant speed and regulating themselves.

In conclusion, I would say, that I hope to see this subject taken up by leaders in electrical science, and given the attention which I think it deserves and which it has not yet received.

MAGNETISM IN ITS RELATION TO INDUCED ELECTROMOTIVE FORCE AND CURRENT.[1]

BY ELIHU THOMSON.

There is, perhaps, no subject which at the present time can have a greater interest to the physicist, the electrician, and the electrical engineer than the one which heads this paper. The advances which have been made in the study from its purely theoretical or scientific side, and the great technical progress in the utilization of the known facts and principles concerning magnetic inductions, can but deepen and strengthen that interest.

On the side of pure theory we find the eager collection of experimental data to be submitted to the scrutiny of the ablest and brightest minds, to be examined and reasoned upon with the hope of finding some clue to satisfying explanations, and, on the side of practice, we find the search for new facts and relations no less diligent, though often stimulated by practical problems presented for solution. Indeed, the urgency for results is often the greater on the practical side, for theory can wait, practice cannot, at least in the United States.

We must look for continued triumphs in both directions, and the most welcome of all will be the framing of a theory or explanation which will enable us to interpret magnetic and electric phenomena. The recent beautiful experiments of Hertz on magnetic waves have opened a fertile region for investigation.

It would seem that the study of magnetism and electricity will give us the ability to investigate the ether of space which medium has been theorized upon at great length, with the result of leaving it very much where it was before, a mysterious necessity.

Faraday says, speaking of magnetism :—

"Such an action may be a function of the ether, for it is not at all unlikely that if there be an ether it should have other uses than simply the conveyance of radiations." 3,075. Vol. iii., Exp. Res.

"It may be a vibration of the hypothetical ether, or a state of tension of that ether equivalent to either a dynamic or a static condition, etc." 3,263. Vol. iii., Exp. Res.

Faraday again says, speaking of the magnetic power of a vacuum :—

"What that surrounding magnetic medium deprived of all material substance may be I cannot tell, perhaps the ether." 3,277. Vol. iii., Exp. Res.

Modern views would seem to point that through a study of magnetic phenomena we may take a feeble hold upon the universal ether. Magnetism is an action or condition of that medium, and it may be that electrical actions are the expression of molecular disturbances brought about by ether strains or interferences. The close relations which are shown to exist between magnetism and light tend to strengthen such views. Indeed it would not be too much to expect that if the mechanics of the ether are ever worked out we should find the relation between sensible heat and electric currents to be as close as that of light to magnetism, perhaps find ultimately the forms of matter, the elements and compounds to be the more complex manifestations of the universal medium; aggregations in stable equilibrium. It is a difficult conception, I confess, and a most shadowy and imperfect one, yet facts and inferences which favor such views are not wanting.

Our science of electricity seems almost to be in the same condition that chemistry was before the work of Lavoisier had shed its light on chemical theory. Our store of facts is daily increasing, and apparently disconnected phenomena are being brought into harmonious relation. Perhaps the edifice of complete theory will not be more than begun in our time, perhaps the building process will be a very gradual one, but I cannot refrain from the conviction that the intelligence of man will, if it has time, continue its advance until such a structure exists.

I have been led to make these general allusions to electrical theory in order to emphasize the fact that in the present paper no unraveling of the mystery is to be attempted, but rather the presentation of some few considerations upon a subject of absorbing interest.

The conception of Faraday in regard to the existence of lines of magnetic force representing directions of magnetic strain or tension in a medium has not only lost nothing of its usefulness up to the present time, but has continually been of great service in the understanding of magnetic phenomena. We need spend no time in showing, as Faraday and others have done, that these lines are always closed circuits, polarized so that the direction of the lines cannot be reversed without reversal of the actions. Nor need we take time to show that in any medium the lines are mutually repellant laterally if of the same direction of polarization. Opposing this tendency to separation or laterial diffusion of magnetic force is the strong apparent tendency of the lines to shorten themselves in any medium. These actions are disturbed by the presentation of a better medium, as iron instead of space or air. Lines of force will move into the better medium, having apparently the constant tendency to diminish the resistance in their paths.

The peculiar and mysterious nature of media, such as iron, is to permit an extraordinary crowding of lines on account of slight resistance to their passage through it. We need not, in addition, do more than refer to the other well-known facts of an electric current developing magnetic lines encircling the conductor, as being the general type, which includes all forms of magnetic field, or electro-

1. A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

magnets, sustained by currents, and the fact of a development when magnetic lines or circuits and material masses are in relative movement of electromotive forces transversely to the direction of the lines of magnetism and also transversely to the direction of relative movement, as in the case of electric conductors traversing or cutting through a field, or of a field traversing or being moved across a conductor. We must not forget that even insulators, as well as conductors, cutting lines of force, have the electromotive force developed in them. The action simply develops potential difference, and this generates the current where a circuit exists. While we are in the habit of saying that a conductor moved across a field of lines, or *vice versa*, generates electric current, I think the statement incomplete. The movement only sets up a potential difference and the power expended in effecting the movement generates $C \times E$. The current is energy less the potential, or the energy expended gives the two effects of potential or pressure, and current or rate of movement. Consequently, an insulator or an open-circuited conductor, traversing a field, consumes no energy, potential difference only being produced. Nevertheless, as will be shown, the magnetic circuits or lines themselves may furnish the energy for their own movement across a conductor, and so develop current as well as potential. This occurs in the effort of lines to shorten their paths, to lessen their density, to pass to better media. Indeed, a close examination will show that wherever power is expended in developing current in a circuit, cutting lines of force, the energy expended is first employed in stretching the lines, which thus receive the energy required to permit them, in shortening, to cut the conductor and set up currents in the electric circuit in accordance with the potential difference developed in that circuit and its resistance.

I think, we may also say, though I do not remember to have seen the statement so put, that whenever electric potential is set up inductively, as in self-induction, mutual induction, induction from one circuit to another and induction from magnets or magnetic field, it is set up by the movement of lines of force laterally across the body, mass or conductor in which the potential is developed, and that whenever current is set up in a wire or an existing current prolonged, or an existing current checked by induction, self-induction or induction from magnets, the action is a transfer of energy, represented by strained lines of force shortening or lessening their resistance, or lengthening and increasing the resistance in their paths. The magnetic field is like an elastic spring, it can in one condition represent stored energy—it can be strained and will store energy—it can be made to relieve its strain and impart energy.

Let us examine some known phenomena in this light. Take the case of a simple wire, conveying current say in a line away from observer, figure 1. There exists a free field of circular magnetism (so-called), shading off away from the wire and which is represented by concentric circles of increased diameter. The superior intensity or strength of the lines near the wire may also be represented by their thickness. This is often shown also by crowding the lines near the wire, though I am disposed to regard figure 1 as more nearly expressing the condition, unless we are to regard the lines as simply indicating a sort of atmosphere of magnetic effect whose density becomes less as we proceed outward from the wire, in which case either form of symbol suffices. The direction of polarization of the lines may be indicated by an arrow head pointing in a direction of right-handed rotation in the path of the lines This is the typical figure or expression for all forms of simple magnetic circuit—the form of the lines, their length, position, density, will depend on the shape of the conductor or conductors (when more than one) and the materials surrounding or in proximity to the wire or wires.

If the current traversing the conductor is constant, the magnetic field around it is stable and static, unless other influences come in to modify it. The cutting off of the current is followed by instability of the field whereby it can and must produce dynamic effects. I say *must* because the field represents stored energy and in disappearing *must* give out that energy. To throw light on this part of the subject is one of the objects of the present paper. Cutting off the current supply in the case assumed leaves the developed magnetic lines or strains unsupported, they at once shorten their paths or circuits, collapsing upon the conductor as it were, and continuing this action, cut the section of the conductor, and apparently disappear in magnetic closed circuits of infinitesimal diameter but of great strength of polarization. It appears to me that we must either be prepared to give up the idea of lines of force or take the position that the magnetic circuits precipitate themselves in shortening their circuits and disappearing upon and cut the conductor. It was Hughes who put forward the idea that an iron bar in losing its apparent magnetism really short circuit the lines in itself as innumerable strongly magnetized closed circuits among the molecules. In becoming magnetic once more these short circuits are opened or extended into the air by some source of energy applied to strain the lines, such as a current in a conductor around the bar.

May not this idea be extended, then, to include the magnetic medium, the ether itself? Does it contain intensely polarized closed circuits of magnetism which are ready to be stretched or extended under certain conditions by the application of energy, which energy is returned by the

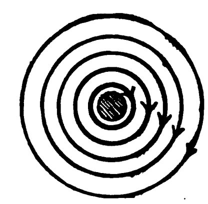


Fig. 1.

collapse of the extended circuits? This is doubtless but a crude expression of the real condition of things, for the lines are only symbols for a condition of strain in a medium which cannot be represented in thought, as we know nothing of its real nature. There is one point in this connection which I must emphasize. The strained lines, figure 1, are indications of stored energy in the ether, and the lines *cannot* disappear without giving out that energy. Ordinarily, it makes its appearance as the extra-current, and adds itself so as to prolong the current which extended the lines when an attempt is made to cut off such current. Were it conceivable that the current could be cut off and the wire put on open circuit while the lines still remained open or strained, the energy must still escape when the field disappears. It would then produce such a high potential as to be able to discharge from the ends of the conductor, and if the conductor were of some section, part of the energy would be expended in setting up local currents in it. The field could not disappear without an outlet for the energy it represents. But we cannot cut off a current in a wire so as to leave the wire on open circuit with the lines of the magnetic circuit remaining around it without iron or steel or the like in the magnetic circuit. We can approach that condition, however, by breaking the circuit very quickly with a condenser of limited capacity around the break. This is done in the Ruhmkorff coil primary; the condenser forms a sort of blind alley for the extra current on its beginning to flow out of the primary coil. But the condenser charges and backs up and stops the discharge from the primary, even giving a reverse current. The lines of magnetic force collapse, however, and have their effect in the enormous potential set up in the secondary coil.

Take away the secondary coil so as to stop that outlet, the energy expends itself on the iron core and the primary

coil. Take away the iron core and the energy of magnetization of the air or ether core expends itself on the wire of the primary and, possibly, also on the dielectric of the condenser to some extent. The extra current becomes in this instance an oscillatory discharge of very high period back and forth through the primary coil from the condenser, until the energy is lost in the heat $C^2 \times R$. This conversion is doubtless rendered all the more rapid by uneven distribution of current and eddy current set up in the wire of the coil.

The considerations just given concern the loss of field or the shortening and apparent disappearance of the magnetic lines or circuits, as giving rise to the self induction or increased potential on breaking. Where the energizing current is slowly cut off or diminished the energy is gradually transferred to the wire in producing elevation of potential during the decrease; and the collapse and cutting of the wire by the collapsing circuits or lines is then only more gradual.

Let the current be returned to the wire after disappearance of magnetism and the lines again seem to emanate from the wire and at the same time cut it and produce a counter potential in it, which is the index of the abstraction of energy from the circuit, and its storing up in the form of elastically strained lines of magnetism around the conductor. The effect is that of self-induction on making or upon increase of current, the measure of the amount being the energy stored in the magnetic circuits which have been extended or opened up by the current. The greater the current and the shorter the path for the lines developed around the axis of the conductor the greater the energy stored up. Hence, a circular section conductor has the highest self-induction, a tube of same section less as its diameter increases, a flat strip has less as its width increases and thickness diminishes, a divided conductor much less than a single conductor of same shape and section. Separating the strands of a divided conductor increases the length of magnetic paths around it and so diminishes the self-induction. A striking instance of this latter fact was developed in conveying very heavy alternating currents of very low potential a distance of about three feet by copper conductors, the current being used in electric welding operations.

The conductors were built up of flat thin strips of copper for flexibility. When the strips were allowed to lie closely together the short conductor showed an enormous self-induction which cut down the effective potential at its ends near the work. By spreading apart the strips so as to lengthen a line around the conductor, the self-induction could be easily made less than 35 per cent. of what it had been before. The interweaving of the outgoing and return conductor strands as one compound conductor, gets rid almost entirely of the self-inductive effects, because neither conductor has any free space in which to develop strong magnetic forces, but is opposed in effect everywhere by the opposite current in its neighbor.

Where a number of conductors are parallel and have the same direction of current, as in a coil or in a strand, it is evident that statically the conductor may be considered as replaceable by a single conductor with the same external dimensions and same total current in the area occupied, the magnetic forces or lines surrounding them being of same intensity. But with changing current strength the distribution of current in the conductor has also a powerful effect on the energy absorbed or given out in accordance with the magnetism produced. Hence, the self-induction of a strand, coil or conductor of the same section varies with the rapidity of current changes, owing to the conduction being uneven.

The uneven distribution of current, or its tendency to flow on the outer parts of a conductor when the rate of variation or alternation is made great, is in itself a consequence of the fact that less energy is transferred into magnetism in this case, than when the current flows uniformly over the section or is concentrated at the centre. In other words, when a uniform current traverses a conductor of the same section the circular megnetism or surrounding magnetic lines are to be found not only outside the conductor, but also beneath its exterior. Since in forming these lines on passage of current the middle of section would be surrounded by more lines than any other part of the conductor, the current tends to keep out of that part and move near to the exterior in greater amount. Hence in rapidly alternating currents the conductor section is practically lessened, being restricted largely to the outer metal of the conductor. If the round conductor, figure 2, were made of iron, the magnetism interior to it and set up by a current in it would be very much greater, the section of the conductor being filled with magnetic circuits or lines

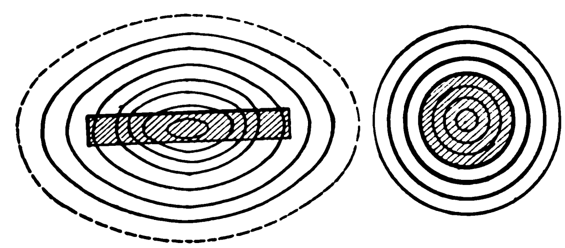


Fig. 2.

around the centre. The total magnetism, external and internal, would be much greater in this case for a given current flow, and the energy absorbed and given out in formation and loss of field, or the self-induction would be much increased. This could, however, be greatly diminished by slitting the conductor radially or making it of a number of separate wires out of lateral magnetic contact, one with the other, figure 3. In these cases the resistance of the interior magnetic circuits would be increased, as there would be several breaks in the continuity around the

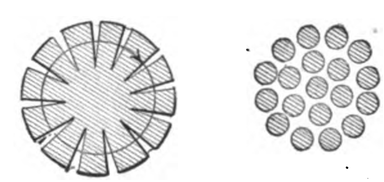


Fig. 3.

centre of the conductor. The total magnetism which could be set up by a current would be lessened, and the self-induction, therefore, lessened.

The moment we begin the bringing of iron into proximity with an electric conductor conveying current, we provide a better medium for the flow or development of magnetic lines or circuits. In other words, the lines may then be longer, yet equally intense, or more lines may be crowded into a given section of this metal than in air or space. Figures 4*a*, 4*b*, 4*c*, show the effect brought about by bringing iron of different forms near to the conductor.

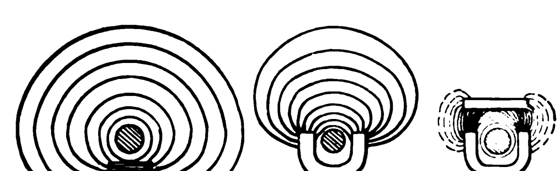


Fig. 4. *a* Fig. 4. *b* Fig. 4. *c*

It shows, in other words, the development of the ordinary electro-magnet of the horseshoe form, and the concentration of the lines in the better medium. The lines also tend to shorten and diminish the resistance to their passage, so that attraction of the iron to the conductor takes place, and if there is more than one piece of iron they

tend to string themselves around the conductor in magnetic contact with one another.

When copper bars of 1 inch diameter are traversed by currents of 40,000 to 60,000 amperes, as in welding them, the magnetic forces just referred to become so enormous that very heavy masses of iron brought up to the bar are firmly held, even though the current be of an alternating character, changing direction many times a second.

When a conductor is surrounded by a cast iron ring, as in figure 5, the current in such conductor has an excellent magnetic medium surrounding it. A large amount of energy is then abstracted on the first impulse of current, which goes to develop strong and dense magnetic lines through the iron ring and across the gap in it. On taking off the current the energy is returned as extra current, and its force is many times what would be found with air alone surrounding the conductor. We have then greatly increased the self-induction, the storing of energy and opposition to current flow at the beginning, the giving back of energy and assistance to the current flow on attempting to remove or stop the current. Let us now complete the ring by making it of iron, endless, figure 6, with the conductor in the middle.

We now find that on passing current through the conductor it meets with a very strong opposing effect or counter potential. The evolution of magnetic lines or the opening out of magnetic circuits goes on at a very rapid rate. Each line or magnetic circuit evolved and cutting the conductor, flies at once outward and locates itself in the iron ring. This ring can carry innumerable lines, and they do not crowd one another. It permits the lines even to lengthen in reaching it, and yet, on account of its low resistance to

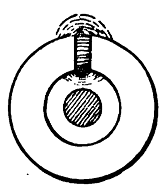


Fig. 5.

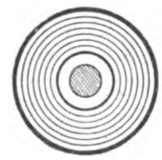


Fig. 6.

their passage, the lengthening is equivalent to their having shortened in other media. We will suppose the current not sufficient to exhaust this peculiar capacity for lines which the iron has. Equilibrium is reached, the conductor has opened up innumerable close circuits and caused them to exist in the ring still closed, but in iron, not space or ether merely. The current passing has continued its action and storage of energy until, to emit another line in view of the resistance now found in the crowded iron ring, is impossible.

Now, let us cut off the current. We are surprised to find a very weak extra current, a practical absence of self-induction on breaking, or at least a giving out of energy in no wise comparable to that on making. Let us put on the current as it was before. Another curious result. But little self-induction now on making, energy not absorbed.

Now cut off the current again. Same effect as before. Now let us put on the current reversed in direction. At once we find a very strong counter potential or opposing self-induction developed.

The ring had been polarized, or retained its magnetic energy, and we are now taking out one set of lines and putting in reversely polarized lines of force. This done, we break the reversed current without much effect of self-induction. The ring remains polarized and inert until an opposite flow of current be sent through. Iron is then a different medium from the ether.

The ring once magnetized must in losing its magnetism permit a closure of the lines by shortening. This involves their passage from the iron across the space in the centre of the ring, notwithstanding its great resistance to the lines of force. As passage from iron to air is equivalent to lengthening of the lines it is readily seen that such lengthening may oppose more effect than a slight shortening due to leaving iron, for air or space may give in provoking a closure and disappearance of the lines. Looked at from another standpoint, the lines on the iron may actually require a small amount of initial energy to dislodge them therefrom, so that after being dislodged they may collapse and yield whatever energy they represent.

I must reserve for the future further consideration of the iron ring, but in thinking upon this matter I am led to think that the production of a magnetic line in an iron ring around a conductor may represent a sort of wave of energy, an absorption of energy on the evolution of the line from the conductor and a slight giving out of energy on the line reaching that position of proximity to the iron ring that its passage thereto may said to be a shortening process or a lessening of its resistance.

The magnetism in air, gases and non-magnetic bodies, being assumed to be that of the ether, this medium shows no such effects as those we get with the ring. It does not become permanently polarized, as does even soft iron under the condition of a closed ring. The iron possesses coercive force, or magnetic rigidity, and a steel ring would show more of it. The molecules of the iron or steel take a set. If we were to cut the soft iron ring or separate it in any way, this introduction of resistance of air for ether in the magnetic circuit would cause the lines to collapse and set up a current in the conductor. The energy of the ring would have been restored to the latter. The curious thing is that physically the polarized ring does not present any different appearance or ordinary properties different from those of a plain ring, and will not deflect a compass needle. Its condition is discoverable, however, by the test of self-induction to currents of different direction. As a practical consideration, we may mention in this connection that a self-inductive coil for currents of one direction must be constructed differently from one to be used with alternating currents. The former must have in its magnetic circuit a section of air or the like, or be an imperfectly-closed circuit, as it were. The latter should have as perfectly closed a magnetic circuit as can be made. We see here also the futility of constructing a Ruhmkorff core coil on the closed iron magnetic circuit plan, because the currents in the primary are interrupted, not reversed.

The considerations just put forward in relation to the closed iron ring, and its passive character under the condition of becoming polarized, are more important than at first appears. It has been found that the secondary current wave of a closed iron circuit induction coil or transformer, whose primary circuit receives alternating current, is lagged from its theoretical position of 90 degrees behind the primary wave an additional 90 degrees, so that the phases of the two currents are directly opposed; or the secondary current, working lamps only in its circuit, is one half a wave length behind the primary, instead of only a quarter wave length, as might have been expected.

But when it is understood that the iron core polarized in one direction by the primary impulse does not begin to lose its magnetism when that impulse simply weakens, but waits until an actual reversal of current has taken place, it will be seen that the secondary current, which can only be produced when magnetic lines are leaving the core and cutting the secondary coil or when the lines being are evolved and passing into the core from the primary coil, will have a beginning at the moment the primary reverses, will continue during the flow of that impulse, and will end at substantially the same time with the primary impulse, provided the work of the secondary current is not expended in overcoming self-induction, which would introduce a further lag. Moreover the direction of the secondary current will be opposite to that of the primary, because the magnetic circuits which are opened up by the primary current in magnetizing the core, or which are closed or collapsed

by it in demagnetizing the core, will always cut the secondary coil in the direction proper for this result. Transformers of the straight core type with very soft iron in the cores and not too high rates of alternation should approximate more nearly the theoretical relation of primary and secondary waves, because the magnetic changes in the core are capable of taking place almost simultaneously with the changes of strength of the primary current. This fact also has other important practical and theoretical bearings.

Let us assume a plain iron core, figure 7, magnetized as indicated, so that its poles N S complete their magnetic circuits by what is called free field or lines in space around it. Let a coil of wire be wound thereon as indicated. Now assume that the magnetism is to be lost or cease, either suddenly or slowly. An electric potential will be set up in the coil, and if it has a circuit, work or energy will be produced or given out in that circuit, and in any other inductively related to it. Hence the magnetic field represents work or potential energy. But to develop potential in the wire the lines must cut the wire. This they can do by collapsing or closing on themselves. The bar seems, therefore, to lose its magnetism by gaining it all, and in doing so all the external lines of force moving inward cut the wire. The magnetic circuits shorten and short circuit themselves in the bar, perhaps as innumerable molecular magnetic circuits interior to the iron medium. To remagnetize the bar, we may pass an electric current through the coil. The small closed circuits are again distended, the free field appears, and the lines moving outward cut across the wire coil opposite to the former direc-

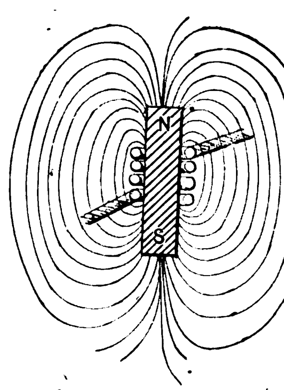


Fig. 7.

tion, and produce a counter potential in the wire, and consequent absorbtion of the energy represented in the free field produced. As before studied, the magnetism cannot disappear without giving out the energy it represents, even though the wire coil be on open circuit, and therefore unable to discharge that energy. The coil open circuited is static, not dynamic. In such assumed case the lines in closing cut the core and heat it. Let us, however, laminate the core or subdivide it as far as possible, and we appear to have cut off this escape for the energy. This is not really so, however. We have simply increased the possible rate of speed of closure, or movement of the lines, and so have increased for the divided core the intensity of the actions of magnetic friction and local currents in the core, the latter still receiving the energy of the magnetic circuit. This reasoning is based on the possibility in this case of cutting off the current in the magnetizing coil and retaining the magnetic field. This is of itself probably impossible with soft iron. That the core receives the energy when the coil cannot, is shown in the well-known fact that in some dynamos with armatures of bobbins on iron cores, the running of the armature coils on open circuit gives rise to dangerous heating of the cores, and that under normal work the heating is less. In the former case the core accumulates the energy represented in the magnetic changes. In the latter the external circuit of the machine and its wire coils take the larger part of the energy which is expended in doing the work in the circuit. In this case, also, the current in the coils causes a retardation of the speed of change and extent of change of magnetism in the iron cores, which keeps down the intensity of the magnetic reaction. In fact, this retardation or lag and reduction of range of magnetic change may in some machines be made so great by closing the circuit of the armature coils themselves or short circuiting them, that the total heat developed in the cores is much less than under normal load.

I wish now, in closing, to refer briefly to phenomena of moving lines of force, and to the effects of speed of movement. In order to generate a given potential in a length of conductor we have choice of certain conditions. We can vary the strength of field and we can vary the velocity. We can use a strong field and slow movement of conductor, or we can use a weak field and rapid movement of the conductor. But we find also that where the conductor has large section it is liable to heat from eddy currents, caused by one part of its section being in a stronger field than another at the same time. One part cuts the lines where they are dense and the other were they are not dense, with the result of difference of potential and local currents, which waste energy in heat. We cannot make the conductor move in a field of uniform density, because it must pass into and out of the field. The conditions just stated are present in dynamos for heavy current work, where the speed of cutting of lines is low and the armature conductor large in section.

But we find that in a transformer secondary we can use very large section of conductor, even (as in welding machines) 12 to 15 square inches solid copper, without meeting appreciable difficulty from eddy currents in it. The magnetic lines certainly cut the heavy conductor and generate the heavy current and potential needed. What difference, if any, exists? In the transformer the currents are generated by magnetic field of very low density, in which the lines are moving across the conductor with extreme rapidity. The velocity of emanation of lines around the primary coil is probably near that of light, and each line passes across the section secondary conductor in a practically inappreciable time. There is no cause then for differences of potential at different parts of the section heavy secondary. Then to avoid eddy currents in large conductors and generate useful currents in them, we may cause the conductor to be either moved into and out of a low density field with very great speed, or better, we must cause the lines of a very low or diffused field to traverse or cut across the conductor with very high velocity.

It is a known fact that in dynamos with large section armature conductors there are less eddy currents produced in the conductors when they are provided with iron cores or wound upon iron cores, than when the conductors are made into flat bobbins moved in front of field poles. Projections existing on the armature between which the conductors are placed have a like effect, and enable us to employ heavy bars or bundles of wire without much difficulty from local currents. The reason is simple. In the armatures with coils without iron in them or without projections extending between the turns the conductor moves into and out of a very dense field at comparatively low velocity, so that any differences of potential developed in the parts of the section of conductor have full effect and abundant time to act in setting up harmful local currents. In the cases in which iron projects through the coil or conductor the real action is that the lines of the magnetic circuits move at high speeds across the conductor, and the conductor is at all times in a field of very low density. Figures 8 and 9 will make this plain. In figure 8 we have shown a smooth armature surface having a heavy conductor laid thereon, and which is at *a*, just entering a dense field at the edge of the pole N and at *b* leaving such field. It will be seen that when in such position the conductor, if wide, is subjected to varying field strength, and moves at a low

speed for the generation of the working potential as it passes through the field, thus giving rise to eddy currents in the conductor.

In figure 9 the conductors are set down between projections, in which case both armature and field poles are laminated or subdivided. As each projection leaves the edge of field pole N the lines which it had concentrated on

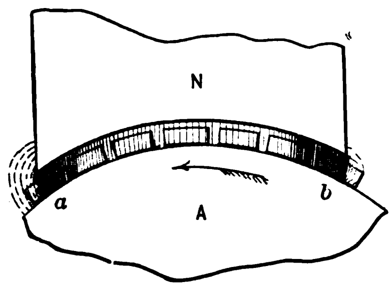


Fig. 8.

and through it snap backward at an enormous speed and cross the gap to the next succeeding projection on the armature, cutting the whole section of the heavy armature conductor at practically the same instant. This brisk transfer of lines goes on from each projection to the succeeding one in front of the field pole, leaving a very low density of field at any time between the projections. The best results would be obtained when the armature conductor

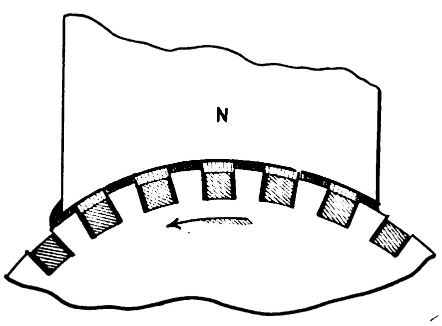


Fig. 9.

does not project beyond or quite fill the depth of groove between the projections. Of course there are other remedies for the eddy current difficulty, notably the stranding and twisting of the conductor on the armature so as to average the position of the parts of the compound conductor.

Perhaps the most extreme case of what may be called dilution of field by projections and by closed magnetic circuits in transformers would be that of a block of iron, B,

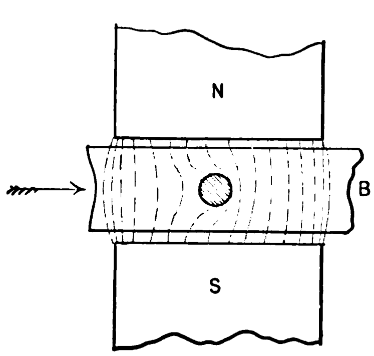


Fig. 10.

figure 10, moved between poles N and S, and having a hole through it, into and through which a conductor is carried. The path through the iron is so good that we can scarcely consider that any lines cross the hole from N to S; yet as B moves forward there is a continual snapping transfer of lines from the right forward side of the hole to the left or backward side, cutting the conductor as they fly across, and developing an electromotive force in it. I have described this action more in detail because we have in it whatever distinction in the manner of cutting the lines of the field is to be found between wire on smooth armatures and on projection armatures and modifications thereof; and also between flat, open coils passing through a field and bobbins with cores of iron. The considerations advanced also bring out the relation which exists between closed iron circuit transformers and closed iron circuit (projection) dynamos, as we may call them.

I had intended at the outset of this paper to deal to some extent with the propagation of lines of magnetism undergoing retardation in reference to alternating current motor devices, transformers with limited secondary current, or constant average current, an alternating motor working with what I may term a translation lag, etc.; but it was soon found that these matters must remain over for a continuation of this paper at some future time. My endeavor has been in the present paper to deal with the lines of force theory as though it were a symbol of the reality, but I confess that it is done with many misgivings that I may have carried it too far. Yet, if we are to use the idea at all, it has seemed but right to apply it wherever it may throw any light on the subject or assist in our understanding of phenomena.

THE INHERENT DEFECTS OF LEAD SECONDARY BATTERIES.[1]

BY DR. LOUIS DUNCAN AND H. WIEGAND.

SINCE the year 1881, when the inventions of Faure gave such an impetus to the industrial development of lead secondary batteries, their commercial history has been marked by numerous and disastrous failures, while at the same time there has been a steady improvement in their construction and performance until at present they have reached a stage which makes them for some purposes a commercial success. At the same time there remain in the best batteries a number of defects which prevent their taking the place in the practical development of electricity which rightfully belongs to them. The action of the secondary battery is quite well understood. In the Faure type a support plate, usually made of lead or an alloy of lead, has mechanically applied to it some salt of lead (minium or lithage). A number of such plates are placed in dilute sulphuric acid, the alternate plates being connected respectively to the + and — poles of some source of electricity, and a current is sent between them. The result is a reduction on the positive plates (the plates through which the current enters) to $Pb. O_2$, on the negative plate to spongy lead. After this "formation" the action, roughly speaking, consists in a reduction of both peroxide and spongy lead to sulphate of lead on discharge, while on charging they are reduced again to their original composition. We find that in the process of charge and discharge there is a loss of energy varying from 15 to 40 per cent. within the practical limits of discharge rate. If we calculate the theoretical storage capacity of a given weight of lead and peroxide, we will find that the plates of even the best modern batteries weigh for the same capacity ten times as much as would those of a theoretically perfect cell. We will find, too, that there is a constant depreciation especially of the peroxide plates, the rate of depreciation increasing with the rate of discharge, and in general depending partly on the way in which the cell is treated, partly on its construction. The principal defects of the modern lead secondary battery are (1) the comparatively small storage capacity, (2) the loss of energy, (3) the depreciation, (4) the low discharge rate necessitated by considerations of efficiency and depreciation.

1. Read before the American Institute of Electrical Engineers, New York, May 22, 1889.

It was especially the question of the loss of energy in the battery that we wished first to investigate. There are two factors which determine the extent of this loss: in the first place, the number of ampere-hours obtained on the discharge of the cell is less than the number put in; and in the second place, the P. D. at the terminals is greater during charge than during discharge. This loss of energy exhibits itself in two ways—in a generation of heat, and in chemical actions which are not reversed on discharge. It is well known that after a cell has been in use for some time, especially if it be submitted to rapid charge and discharge, there will be found in the bottom of the containing vessel a white, powdery deposit, a sulphate of lead which has been formed from the active material of the plates and which has not been afterwards reversed. Again, when the cell is charged we find bubbles of gas escaping from the plates during almost the whole of the charge, the escape becoming quite violent towards the last. The escape is at first principally from the positive plate, but afterwards it is from both plates. This escape represents, of course, a loss of energy due to the electrolysis of the dilute acid in the cell, the products being free hydrogen and oxygen.

Let us consider what takes place during the charge and discharge of a cell. Supposing the cell to have been discharged until its P. D. has dropped to 1.8 volts, on beginning to charge the P. D. increases until it reaches a value of about 2.1 volts—at a normal charge rate,—then increasing very slowly during a considerable portion of the charge, then increasing faster until it reaches a value of from 2.4 to 2.5 volts, when the cell is "boiling." The chemical action results principally in the reduction of the sulphate of lead on the two plates to peroxide and spongy lead respectively. The greater the charge rate the higher will be the P. D., and the sooner will the cell begin to boil, and the greater will be the loss.

On discharge the P. D. drops to from 2 to 1.95 volts for normal discharge rate, where it remains during the greater part of the discharge, there being a gradual fall during the latter part to 1.8 volts, when the discharge should cease. If a high discharge rate be employed, there is a decrease in the capacity and efficiency, and a more rapid depreciation. If the discharge be continued after the P. D. has dropped below 1.8 volts, there will be a formation of white sulphate on the plates, there will be a loss of energy, as will be shown, and there will be a rapid depreciation of the cell. The result of the discharge is a formation of sulphate of lead on both positive and negative plates. If we test the specific gravity of the solution at different times we will find that the solution has a maximum strength —say 1.200—when fully charged, with a minimum on discharge—say 1.150,—the sulphating of the lead decreasing the strength of the solution. The number of ampere-hours obtained on discharge is less than the number put in by an amount depending on the construction of the cell and the conditions of charge and discharge. There is a further apparent loss of energy in the fact that the electromotive force on discharge is less than that during charge.

Our first experiment was made to determine, if possible, whether part of this difference of E. M. F. was not due to the fact that the strength of the solution *in the plugs* varied, it being stronger during charge than during discharge. During discharge the sulphuric acid in the plugs has its strength decreased by the sulphating of the lead or peroxide. This weakening continues until the diffusion of the stronger acid in the cell produces a condition of equilibrium. It is known that the electromotive force of a cell varies with the strength of the solution, being higher as the strength increases. Gladstone and Tribe have found that when the acid is very weak the chemical action is changed, the result on a positive plate of sheet lead being the formation of streaks of a mixture of yellow and puce-colored oxides, while on other parts a white substance is formed, which is easily detached, falling in clouds into the liquid. This white substance is probably a basic sulphate of lead. When this action takes place the corrosion of the plate is more than doubled. So if the diffusion in the plug is slow, it may very well happen that there will be a great difference of density during charge and discharge, causing a difference in electromotive force and a formation on discharge of chemical compounds which are not afterwards reduced. A rapid discharge rate would tend to greatly weaken the acid, and therefore to decrease the efficiency and hasten corrosion of the positive plate.

To find the rate of diffusion we soaked the plates or single plugs to be experimented on in acid of a specific gravity of 1.175, and then placed them in vessels of distilled water, letting them remain for different intervals of time, and determining the amount of acid diffused out into the water. To give some idea of the magnitude of the result, I select the following figures from a number of experiments. The plates used weighed about a pound and a half (.7 kilos.), and were of the grid type :—

POSITIVE PLATE.

CHARGED.		DISCHARGED.
Time in water.	Acid diffused.	Acid diffused.
1 min.	.695 grms.	.29 grms.
5 "	1.41 "	.60 "
30 "	2.50 "	1.43 "

NEGATIVE PLATE.

CHARGED.		DISCHARGED.
Time.	Acid diffused.	Acid diffused.
1 min.	.86 grms.	.317 grms.
5 "	1.42 "	.700 "
30 "	3.05 "	1.35 "

The curve shown in figure 1, gives the diffusion from a charged positive plate.

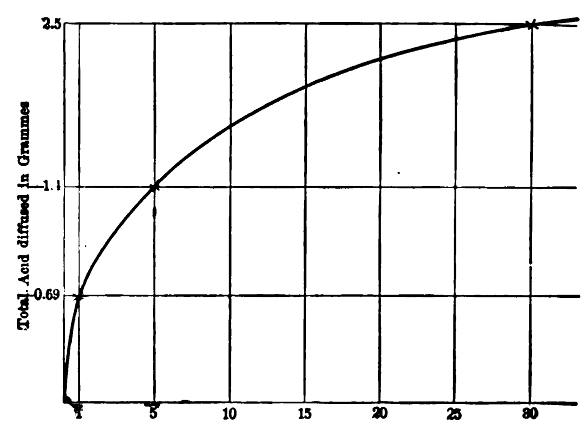


Fig. 1.

The total amount of acid in the charged positive plates was (25 grms. of 1.175) about 5 grms.; so it will be seen that the rate of diffusion of the acid in the interior of the plugs is slow, for after 30 minutes, when half of the acid remains in the plug, the rate of diffusion has decreased from about .7 grammes for the first minute, to about .025 grammes per minute. While this is hardly the condition of affairs in actual practice where the rate at which the acid is being added or abstracted varies in different parts of the plug, yet it gives us some idea of the magnitude of the quantity. It should be noted that the rate of diffusion is materially the same for positive and negative plates, but that the rate for a discharged is considerably less than that for a charged plate. Keeping these facts in mind, let us pass to the phenomena of charge and discharge.

To investigate the loss of energy from heating, we placed the cell to be experimented on in a wooden box lined with a layer of felt about an inch thick. There was a top for the box, also lined with felt, and through it passed the rod of a stirring paddle and the stem of a thermometer.

Experiment showed that the loss of temperature in this arrangement was for a

Difference between air and box.	Degrees loss per Degree diff. per hour.
7.2°	.12°
5.1	.1
4.2	.95

In the experiments we tried as nearly as possible to keep the air and cell at the same temperature, and the correction for radiation could usually be neglected. The cell was charged and discharged under a number of conditions, and the rise of temperature and other data were observed. The losses of energy that occur must, as has been stated, exhibit themselves in heat or in chemical changes which are not reversed. The cell was of the grid type, with 4 positive and 5 negative plates. The weights were :—

Total weight	25 lbs., 3 oz.
Weight of plates	17 " 8 "
" " vessel	1 lb., 3 "
" " solution	6 lbs., 8 "

This gives a neat capacity for the cell such that the energy lost is approximately 3.2 watt-hours per degree.

The cell was first charged at 5 amperes until over 150 ampere-hours had been put in ; both positive and negative

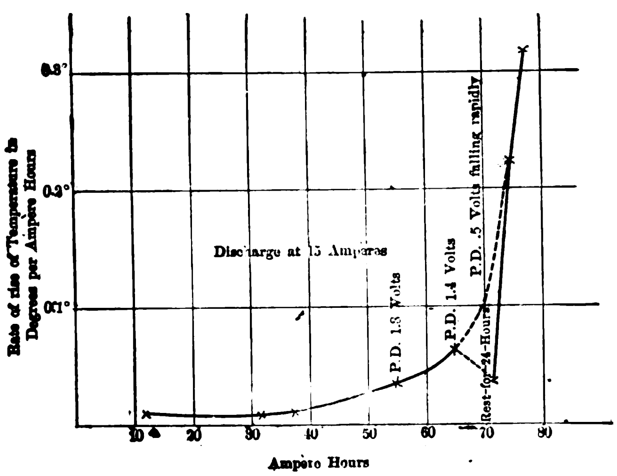


Fig. 2.

plates were boiling freely. The discharge was at a rate of about 15 amperes. Some of the particulars of the discharge are :—

Ampere-hours discharge.	Rate of rise of temp. per amp.-hour.	Total rise of temp.	$C^2 R$.
10	.012	....	....
20	.01	....	....
30	.008	....	....
40	.015	....	....
50	.03	....	....
60 P. D. falling.	.05	2.03	11 watts.
70	.12	....	....
77	.30	3.75	13 watts.

In this case the discharge was carried far beyond the limit of economical discharge. It will be seen that the loss is greater as the discharge continues, increasing slowly until the E. M. F. begins to drop, when it rises very rapidly.

After this discharge the cell was charged at a rate of 10 amperes.

RATE OF RISE.

Ampere-hours.	Degrees.	Total rise.	C^2 R.
20	.04	....	....
40	.04	....	....
60	.05	....	....
80	.08	4.7	8
100	.166	8.9	....
120	.20	11.5	12

The cell thus charged was discharged at a rate of about 20 amperes. The rate of rise of temperature was very much as in the case of the discharge at 15 amperes. The total rise, with the P. D. down to 1.7 volts, 60 amperes having been taken out, was $1^\circ.1$; on further discharge down to .7 volts, taking about 20 ampere-hours more from the cell, the rise was 4.1°. This again shows that the loss increases as the P. D. falls.

The next charge was at 20 amperes. The rate of rise of temperature is given by the curve, figure 4. The total rise was 30.7°. The rise for 100 ampere-hours was 11.5°. The corresponding values of C^2 R. were 34 watts and 20 watts.

The effect of a rest is shown on the portion of the curve between 105 and 120 amperes, where a 16-hour rest gives

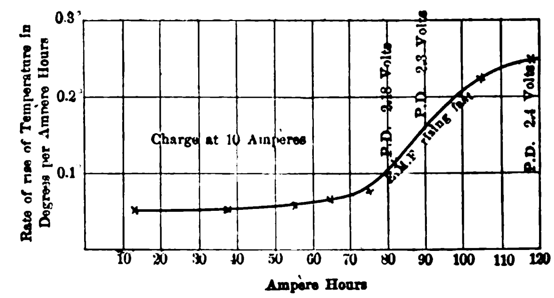


Fig. 3.

a considerable reduction in the rate of temperature increase. The maximum rate is about .3 degrees per ampere-hour.

The cell thus charged was discharged at a rate of 30 amperes. The discharge was divided into periods of 20 minutes, with periods of equal length between, the object being to determine, if possible, whether there is a local action in the mass of the plug due to the different chemical conditions of the different parts of the plug, which would especially be the case if the charge or discharge were rapid. As in the previous case of discharge, the rise of temperature was slow, there being a gain of but 1.3° for a discharge of 40 ampere-hours, the heating effect of the current in that time being 12 watts, equivalent to almost 4°. For the first three periods there was little if any rise during the time of repose ; for the fourth period there was a rise of about .1°, or .3 watt hours. During the fifth period the E. M. F. began to fall, and during repose after it the temperature rose .15°. The sixth discharge period was with the same current, but at a greatly reduced P. D. and resistance. It lasted 12 minutes ; after it the

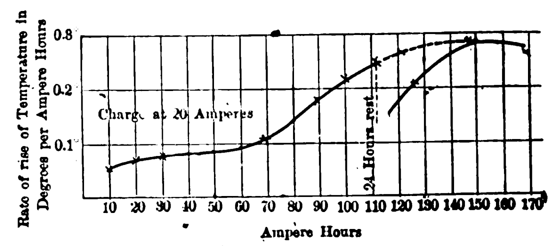


Fig. 4.

temperature rose .5°, corresponding to 1.5 watt hours. The output of this discharge was 44 ampere hours at a normal P. D.; 11 at a low P. D. The total rise of temperature was 3.5° ; the value of C^2 R was 16 watts.

The cell was then charged with 70 ampere-hours at 30 amperes, the same periods of repose being allowed. There was a definite rise amounting on the average to about .2° ; after the first period the rise was but .1°, the others slightly over .2. The details of the charge were :—

Ampere-hours.	Rise in temp.	Rate.	C^2 R.
15	1.	.067	4.5
40	4.4	.18	11.5
70	13.1	.29	20.5

The details of the discharge at 30 were :—

Ampere-hours.	Rise.	Rate.	C^2 R.
10	.14	.014	3.2
25	.63	.032	7.7
35	1.02	.04	10.7
45	1.63	.06	13.7
54 P. D. fell.	2.63	1.1	16.5

The rise during the periods of rest for this discharge was at first small, but afterwards something over .2°.

The next charge was at a rate of 40 amperes. The following are the figures :—

Ampere-hours.	Rise of temp.	Rate.	C^2 R.
20	1.5	.075	8.
42	3.9	.11	15.
63	8.0	.20	22.
80	13.2	.3	28.
97	18.65	.32	34.
	Rest.		
106	21.35	.30	36.75

The rise during periods of repose was .1° for the first period, .7° for the second, and decreased as the charge increased until it reached a value of about .2°.

The discharge corresponding to this charge was also at 40 amperes, and was divided into periods as before.

Ampere-hours.	Temp.	Rate.	C^2 R.
14	.46	.033	5.
28	1.16	.05	11.
42	2.24	.077	17.

Whether the rise in temperature during the periods of rest is due to the heat of the plates being diffused into the liquid, or is due to a local action in the plugs is difficult to determine. If it were due to local action we would expect a greater rise during the first periods of the charging experiments, and this is what we find. If it were due simply to diffusion of heat, we should have approximately the same effect at corresponding periods of charge and discharge, the rates being the same, but we see that it is greater during some of the charge than during corresponding discharge periods, and it is not uniform even during charge and discharge, it being sometimes greater when the resistance of the cell is less. Some of the rise is undoubtedly due to the diffusion of heat from the plates, but it seems certain that a part of the effect is due to the local action.

Our next experiments were with negative and positive plates which were in different conditions of charge and discharge. At first a cell was made up of fully charged negative plates, with positives from which 45 ampere-hours had been taken, and it was discharged in the calorimeter at 10 amperes.

Ampere-hours.	Rise.	Rate.	C^2 R.
4.2	.05°	.012°	.5
17.5	.20	.011	1.8
Rest.			
35.8	.45	.009	2.6
49.1	.85	.03	4.0
66.1 P. D. fell.	3.05	.13	6.0

Next a cell with fully charged positives and negatives from which 47.5 ampere-hours had been taken, was discharged at a rate of 5 amperes.

Ampere-hours.	Rise.	Rate.	C^2 R.
10.	—.1°	—.01°	.5
15.5	—.15	—.01	.75
20.5	—.20	—.01	1.00
23.	—.20	.00	1.1
29.	—.20	.00	1.4
34.	—.20		1.65
39.	—.17	+.008	1.9
41.5	+.05	+.08	2.05
Rest.			
47.5	+.28	+.04	2.45
49.5 P. D. fell.	+.50	+.11	2.55

Cell short-circuited, for very small current.

1 hour.	+ .30
6 hours.	+ 3.00
11 hours.	+ 5.2
22 hours.	+11.2
23 hour.	+11.8

After this exhaustive discharge the cell was charged at five amperes, attempts at discharge being made at intervals. At first the P. D. fell at once on closing the discharge circuit, but after about 16 ampere-hours had been put in a discharge of five amperes for eight minutes was obtained. The temperature, which had been rising quite fast, began to rise slowly at this point, the rates being given by the curve.

The cell boiled with a charge of 117 ampere-hours, when the total rise of temperature was 96°, C^2 R = 7 watts. For a charge of 160 ampere-hours the rise was 17.3° with C^2 R = 9 watts.

Another discharge of a negative cell which had 58 ampere-hours taken out gave :—

Ampere-hours.	Rise.	Rate.	C^2 R.
9	0°	0°	.5
22.2	.39	.019	2.0
31.0 P. D. fell.	.61	.026	2.5
34.2	.90	.09	2.7

This gave the total capacity of the negative plates at a discharge rate of five amperes as about 90 ampere-hours; the previous experiment gave 93. The capacity of the positive plates was 94 ampere-hours. It was noticed in these experiments that when a partly run-down negative was used, the fall of potential after a value of 1.5 volts was reached, was very rapid. From 1.3 to .5

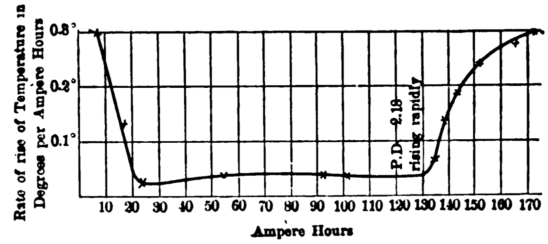


Fig. 5.

volts took less than a minute, while in another minute the value had reached .25 volts, and it was soon only a few hundredths of a volt. With the discharged positive, on the contrary, the fall was slow. After a value of 1.35 was reached, the fall in a half-hour was only to 1.04 volts, and in four hours it was .66 volts. After several hours short circuit, when the value had reached a few hundredths, the circuit was broken. In five hours the value was 1.65, and the next day it was 2.02 volts. With some plates made by depositing thin layers of spongy lead and peroxide on lead support plates, the effect was still more marked. Here the P. D. of a negative plate fell from a value of 1.8 to .05 in ten seconds; while with the positive the fall was gradual.

Now let us see what our experiments, as far as we have carried them out, show. In the first place the loss that exhibits itself in heating increases as the charge or discharge goes on, not being very great in the latter operation until the P. D. has begun to fall. The loss is greater during charge than during discharge. For instance, take a discharge at 15 amperes, the P. D. begins to fall when 60 ampere-hours have been taken out. The total rise in temperature is 2.03 degrees, while the rise due to the heating of the current alone (C^2 R) should be 3.4°. In other words, there has been an absolute lowering of the temperature by all the other actions outside of the Joule effect. Taking a charge at 10 amperes, the rise for a charge of 100 ampere-hours was 8.9°, with a loss due to the Joule effect corresponding to 3°, a difference of 5.9°. The difference in the losses for charge and discharge—

neglecting C^2 R—is about 5.3°. For a charge of 120 ampere-hours, the rise was 11.15°.

We will find the same results in all of the other records, there being sometimes an absolute fall of temperature on discharge. This is without doubt due to the fact that the acid is strengthened on charge, weakened on discharge. In changing from a specific gravity of 1.14 to 1.18, the evolution of heat is such as to raise the temperature of the solution about 3.2°; there will be a corresponding cooling effect on discharge.

To the above charge, at 10 amperes there was a discharge at 20 amperes, which gave a total of 84 ampere hours, of which 60 were at normal P. D.; the rise for normal P. D. was 2°; the total rise was 4.7°. C^2 R = 12.1 watt-hours for the 60 ampere-hours at normal P. D., corresponding to 3.8°; the total value of C^2 R for the 84 ampere-hours was 15.1, corresponding to 4.7°. The total heat loss in the process of charge and discharge was 11.5 + 4.7 = 16.2°, or about 51 watts. The total loss obtained from taking the difference between charge and discharge energies, calculated from the ampere-hours and potential difference, was 98 watts, more than half of which appeared as heat. Of the 51 watts which appeared as heat, 27 were due to the Joule effect, 34 to other causes. We believe that part of this loss—a very small part—is due to local action between the positive material and the support plate. Another part is due to local currents in the plugs themselves. When the plate is charging or discharging, the distribution of current in the plug is not uniform, but it is denser at the surface than in the interior. After a while the plug is not uniform in its chemical composition, and there are doubtless eddy currents in such a way as to tend to bring the plug to uniformity of chemical condition. These will be more important as the current rate increases. The last part of the charge of the cell consists largely in the electrolysis of the dilute acid with a liberation of oxygen and hydrogen. It is known that heat is generated in this process, the amount depending on the density of the acid and the nature of the electrodes. M. Gramme in some experiments on the electrolysis of water, only utilized 50 per cent. of the energy expended in producing electrolysis, the remainder being lost. In our own case, when the charge has reached such a point that the reduction of the plates is complete, and the principal action is the electrolysis of the solution into free hydrogen and oxygen; if the total P. D. is 2.5 volts, and if the energy of combination of oxygen and hydrogen corresponds to about 1.5 volts, we may expect of the energy of 2.5 watt-hours, corresponding to a charge of 1 ampere-hour, 1 watt-hour to appear as heat. If we look at the tables, we will see that the rate of rise of temperature for overcharge is in the neighborhood of .3° per hour per ampere, and this corresponds to about 1 watt, as we would expect. As this action (shown by the evolution of gas from the plates) continues through the whole of charge and part of the discharge (doubtless due to local action in the latter case); we will always have *some* corresponding rise of temperature, although it will not reach its full value until the cell is boiling.

The rise of temperature then, is due to :—

(1) The Joule effect, 27 out of 51 in this case.
(2) Currents caused by local action between active material and support.
(3) Currents caused by local action in plugs.
(4) Heat losses corresponding to electrolysis of solution into free oxygen and hydrogen.

The last three probably account for the remaining 34 watts.

But there are 47 watts left unaccounted for, which must be due to chemical changes not reversed. The most important of these, *as far as loss of energy is concerned,* is doubtless the formation of free hydrogen and oxygen. Another component of the 47 watts is due to the local action between the plugs and support. But we believe the most important, as far as *deterioration* is concerned, is in the formation of irreversible compounds caused by the weakening of the acid in the plugs. We have found that the rate of diffusion in the plug is comparatively slow, so that during a rapid discharge there must be weak acid in the plug. Where the outer layer of active material is reduced, the inner layer is surrounded by weak acid, causing a lowering of the E. M. F. and corrosion, as described by Gladstone and Tribe, with a considerable local action between the outer and inner layers. As the rate of diffusion is less with a partly discharged than with a charged plate, a heavy discharge rate has a more marked effect with a partly discharged than with a fresh cell, as experience has shown.

These are, we believe, the principal sources of loss in a lead secondary battery, and the depreciation can be mainly charged to them. The expansion and contraction of the plugs in a grid plate is another source of trouble, and cannot be avoided. Our own experience has been that the losses are less with plane plates, coated with thin layers of active material, than with plates made of the grid form. Under any circumstances, an increase of surface for a given current rate is to be desired, as it lengthens the time of charge before the violent boiling occurs. A plane plate gives a uniform distribution of current, and, therefore, very little local action.

ABSTRACTS AND EXTRACTS.

DETERMINATION OF THE SPECIFIC RESISTANCE OF PAPER.

(From the Electrical Experimental Station, Munich.)

It sometimes becomes necessary, in the pursuit of an investigation, to know the specific resistance of various sorts of paper and card. From the nature of the substance, the determination of this specific resistance can have no claim upon exactness—it serving only as a more or less close approximation, as it is clear that the moisture of the air influences, to a very great degree, the resistance of the paper. In the experiment conducted at this station, the following connection scheme was employed :—

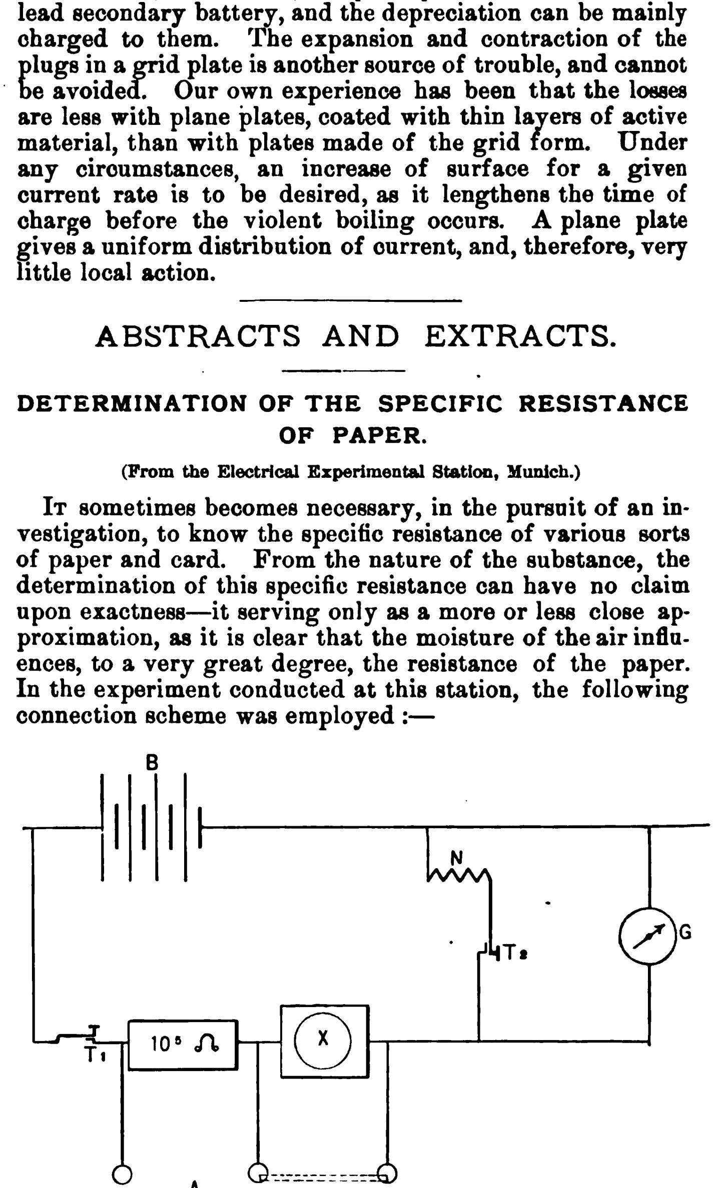


Fig. 1.

A chromic acid battery of 16 cells was used, which when freshly filled gave an E. M. F. of about 30 volts. The galvanometer G, has a resistance of 5,000 ohms. Its sensitiveness was determined by being shunted with 20 ohms while 100,000 ohms were put in the main circuit. By this connection the galvanometer gave, with 16 elements, a deflection of 34 mm. This value corresponds to the introduction of 16^6 ohms without shunt—theoretically a deflection of 936 mm. By dropping the bent wire A, into either pair of mercury cups, the 10^5 ohm resistance, or the experimental apparatus X can be either connected or disconnected as the

case might be. If the 10^8 ohm is in circuit, then the key T_2 must be closed, and afterwards key T_1.

The apparatus used in the experiment is represented in figure 2.

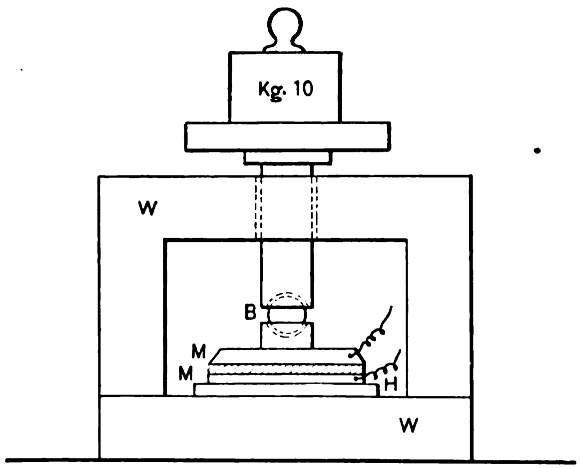


Fig. 2.

It consists of two flat sheets of brass, M M, which rest upon a hard rubber plate H, inside the wooden frame W W. The pressure of an iron rod passing through a hole in the framework is communicated to the upper brass plate through the glass ball B. This ball serves as well for better insulation as for the better distribution of the pressure. On the upper end of the iron rod is a stand on which is to be placed the heavy iron weights.

The tabulated result of the experiment is as follows :—

Material.	Pressure in kg.	α	Resistance.	Specific resistance.
Ordinary card-board.	0	0.5	1860×10^6	4850×10^{12}
2.3 mm. thick.	1	1.0	930 "	2430 "
6,000 q. mm. area.	2	1.0	930 "	2430 "
	5	1.6	580 "	1580 "
	10	2.3	405 "	1054 "
	20	3.3	280 "	467 "
Grey paper.	0	5.7	162×10^6	3100×10^{12}
0.26 mm. thick.	1	7.5	124 "	2700 "
5,000 q. mm. area.	2	8.2	114 "	2500 "
	5	12.5	74 "	1600 "
	10	15.3	61 "	1320 "
	20	25.0	37 "	800 "
Yellow parchment paper.	0	1.8	520×10^6	30500×10^{12}
0.09 mm. thick.	1	14.5	64 "	3770 "
5,300 q. mm. area.	2	19.2	48 "	2830 "
	5	28.0	33 "	1940 "
	10	40.0	23 "	1350 "
	20	63.0	15 "	880 "
Tracing cloth.	0	7.5	124×10^6	13500×10^{12}
0.055 mm. thick.	1	10.5	88 "	9600 "
6,000 q. mm. area.	2	6.9	132 "	14600 "
	5	19.5	48 "	5230 "
	10	17.0	55 "	6000 "
	20	55.0	17 "	1860 "

The values for the last material show great irregularity. The thickness is so very small that the taking off and setting on of the weights causes disturbance enough in the particles of the substance, to make this great change in its electrical resistance.—F. UPPENBORN in *Centralblatt für Elektrotechnik.*)

TELEPHONE CONDUCTORS.

BY R. W. JAGGARD.

IT is of great importance that the proper size of telephone wires should be ascertained, both from the commercial and from the scientific point of view. The two things to be considered are initial cost, and freedom from induction.

An experimental cable, laid on the Pennsylvania Railroad between the Broad street and Thirty-second street stations, in the spring of 1887, contains 53 conductors, 52 of them are number 16, and one is number 18, American gauge. The greater number of the conductors are used for telegraph purposes, and a part of the remainder for telephones.

About a year ago a phonoplex circuit, working between Philadelphia and Harrisburg, was introduced into the cable. The heavy inductive impulses used to operate this circuit caused considerable disturbance on the telephones. An attempt was made to ascertain which of the conductors was least disturbed by those inductive impulses, and it was found to be the 18-gauge conductor, the electrostatic capacity of which was about 0.11 microfarads per mile, while the 16-gauge conductors averaged about 0.14 microfarads measured on a cold night at a temperature of 12 degrees Fahrenheit.

Substituting the 18-gauge conductor for one of the 16, we increase the resistance of the circuit, including the telephones, not quite two per cent.; but the electrostatic capacity is reduced over 20 per cent.

Two per cent. increase in the resistance of the circuit could not be felt in operating the telephones, but a decrease of 20 per cent. electrostatic capacity was clearly discernible in greatly lessening the inductive disturbances; and on that account, the 18 gauge was selected for the most particular telephone circuit.

As a majority of telephone circuits diverging from the exchanges are less than a mile in length, it is evident that smaller-sized conductors with greater insulation should be used. Not that high insulation is desirable, but that the thicker the covering and the smaller surface of conductors is a principle that would be well to follow. This principle was proved conversely by using two 16-gauge conductors in place of a single conductor, which doubled the inductive disturbances, in the same proportion to the increase in electrostatic capacity; at the same time the resistance of the conductor was halved.

Carrying out the above principle, it is evident that small conductors are advantageous as long as the conductors are confined to cables within the area of cities; but when extending beyond city limits, they should be connected with wires of larger dimensions, especially so when metallic circuits are used, as in long-distance working. In cases of this kind conductors can be transposed and crossed on the poles to neutralize, or nearly so, all inductive disturbances.

There is another feature worthy of notice in laying up the conductors of a cable in order to reduce the electrostatic capacity. Cotton has exceedingly low electrostatic capacity, and, as is the case of the cable above mentioned, the conductors are all twisted tightly in the same direction like the strands of a rope, allowing the cable to absorb a minimum amount of the resin mixture, which has a much greater electrostatic capacity than cotton. By this means the electrostatic capacity of the conductors is very low.

It is very plain, therefore, that even for metallic circuit purposes there are no advantages to be gained by having the conductors twisted in pairs, as the cable then becomes more bulky, and fewer wires can be put in the same diameter of pipe. There is also a greater space within the cable itself to be filled up by the resin mixture, thereby increasing the electrostatic capacity.

In Brooklyn a number 19 American gauge conductor, having three windings, laid up in pairs, is reported as having a capacity of about 0.19 microfarads per mile, while this cable with a number 16 conductor and two windings shows but 0.14 microfarads at the temperature mentioned.

The New York and New Jersey Telephone Co. sent an electrician to Brooklyn to measure the electrostatic capacity of these conductors. That company is able to furnish comparative results.

Vice-President Thomson, of the Pennsyslvania Railroad, uses two of these conductors in connection with the long-distance telephone lines to New York, and the service is said to be quite satisfactory.

It should be borne in mind that the electrostatic capacity of the metallic circuit is but one-fourth of the sum of the two sides when the capacity is taken as two separate conductors. Using the second wire in place of the ground for the other pole of the battery, with both conductors open at the distant end.

Similarly, the insulation resistance is double that of the sum of the resistance taken in the usual manner. For example: if one conductor should measure ten and the other five megohms per mile, when insulation is taken in the usual manner with one pole of the battery to earth. If the other pole of the battery is then connected to the second conductor, the lines of insulation resistance on one side, 10 megohms to earth and out of earth to the other conductor, five megohms, which makes the insulation of the metallic circuit 15 megohms per mile.

The foregoing hints are more especially intended for those who are about to open new telephone exchanges with underground or cable conductors in any form, and should receive the careful consideration of telephone managers, who, as a rule, are more commonly selected for business qualifications than electrical knowledge.

Electricians, as a general rule, are not good business men, and managers generally copy after some other managers, but, "if the blind lead the blind they both fall into the ditch," which is the scriptural name for conduit.

The use of large size conductors in short-distance telephone working reminds me of the lack of scientific knowledge when the first Morse telegraph was put into operation. They had an idea that the same size conductor should be used in making the relay that was used for building a line, and thereby employed a number 14 copper wire to wind upon the iron core. Sixty cells of Grove's battery were required to operate a line forty miles long, and the magnetic effect was so weak that it required the most delicate adjustment to enable the armature to be moved. With that sized wire but few convolutions were brought into proximity to the iron core. This difficulty was overcome by using a wire of smaller dimensions.

It can be readily seen, therefore, that large-sized conductors are not always advantageous.—*The Electrical Engineer* (London).

CORRESPONDENCE.

NEW YORK AND VICINITY.

Removing Overhead Wires.—Another Subway Explosion.—Consideration of the Bids for Street Lighting.—The Growth of Electrical Interests at a Standstill.—Another Injunction Against The Board of Electrical Control Asked For.—Captain Zalinski Appointed Military Attache at St. Petersburg.—The First Criminal Sentenced Under the Electrical Execution Act; Details and Cost of Apparatus.—Loss by Fire of the Harlem Electric Light Station.—Mr. Francis B. Crocker Appointed Instructor of Electrical Engineering at Columbia College.

THE crusade against the overhead wires has continued without cessation from the day the first order was sent out by the Mayor. During the first week in this month the telephone lines in the upper portion of the city, including the "Long Distance" line in Fifty-eighth street, came down. By the removal of electric light wires, Madison square and upper Broadway were left to the feeble glimmer of an occasional gas jet. The public, however, who had begun to congratulate themselves upon the removal of the "mysterious death-dealing agency in the wires"—so frequently alluded to by the daily press—are becoming alarmed at the periodical explosions in the subways, and wayfarers avoid all kinds of man-holes. An explosion in the subway occurred at the northwest corner of Fifteenth street and Broadway, May 13th, at night. About three feet of the street rose into the air and settled back in a heap, no further damage resulting.

With one exception, the bids of the electric light companies for street lighting were doubled in the subway district. Upon opening these bids, the Mayor is said to have loudly exclaimed: "We'll use gas." But the Mayor knows that property owners would never consent to resume gas again for lighting Broadway and other prominent streets.

The attitude of the present Mayor is in strong contrast to that of Mayor Hewitt, and the electric companies necessarily have adopted a defensive policy in the management of their interests. We have comparatively a very large amount of undeveloped territory; and, although capital stands ready to furnish electric lighting wherever required in the city, such a thing as developing the business is hardly to be considered until something more practicable and comprehensive than the present subway system be provided.

One central station, with a capacity of 2,000 incandescent lights, has been shut down for a month, not being allowed to run a single wire; and, as a matter of fact, all of the electric lighting industries of the city are more or less seriously crippled. Since the issuance of stringent rules and regulations by the board, the rivalry between the different stations has been shown by the institution of a close watch on each other's work, and a report of violations to the board.

Notwithstanding the failure of the Western Union Telegraph Co. to secure an injunction against the Board of Electrical Control, the result of their suit being practically to establish the legality of the board by the Federal and State courts, the American Rapid Telegraph Co. brings a suit (May 16) in the Supreme Court, praying for an injunction. The brief reiterates the points and arguments employed by the Western Union company in a similar suit, and attacks the constitutionality of the contract made by the board with the Consolidated Telegraph and Electric Subway Co., which gives them authority to build all electric subways and to collect tolls or rents for the use of same. The complaint acknowledges that its lines and property are in the possession of the Western Union Telegraph Co. as agent for the Receiver, and it is suspected that the suit is merely a shrewd move to gain additional time.

Captain E. L. Zalinski, of the United States Army, the well-known inventor of the pneumatic dynamite gun, has sailed for St. Petersburg, to assume his duties as military attaché of this government.

The warrant for carrying out the death sentence of the first criminal convicted under the new law providing for electrical executions has been signed, but owing to probable further judicial proceedings it is not expected that the sentence will be carried out very soon.

Mr. Harold P. Brown, 45 Wall street, has contracted to furnish three sets of apparatus (as given below) for $8,160.

One 650-light alternating-current dynamo, with electromotive force variable at will from 1,000 to 2,000 volts; each dynamo to be furnished with an exciter and a rheostat; one Cardew voltmeter, with extra resistance coil, calibrated for a range of 30 to 2,000 volts; one ammeter for alternating currents from 0.1 to 3.00 amperes; one Wheatstone bridge and rheostat; six switches; three sets of electrodes; three sets of bell signals; 4,000 feet, more or less as required, water-proof insulated wire of high insulation resistance, and a sufficient number of insulators for same.

Mr. Brown has been giving the state prison wardens instructions regarding the use of the apparatus, and will officiate, it is said, at the first test. Mr. Brown has opened a business office at 45 Wall street, and in view of the passage of electrical execution laws in several other states, expects plenty of business.

The fire of April 25th, which consumed the Central Station of the Harlem Electric Light Co., caused a loss of $100,000.

Mr. Francis B. Crocker has been appointed Instructor of the Department of Electrical Engineering of Columbia College, and Mr. Michael Pupin, Assistant Instructor. This department was formally opened Monday, May 13th.

Mr. Charles H. Davis, C. E., has opened an office at 120 Broadway. Mr. Davis will undertake electrical contracting.

NEW YORK, April 22, 1889.

PHILADELPHIA.

The Lehigh Avenue Electric Railway.—The Underground Wire Question.—Liquidation of the Philadelphia Welsbach Incandescent Gas Light Co.

THE officers of the Lehigh Avenue Passenger Railway Co. expect to have their road, which is a little over three miles in length, in full operation within five weeks. Six storage battery electric cars are being built for the road by the Electric Car Co. of America, in this city, and when first put on the road will run on 10-minute time. Five of the cars are to be four-wheeled and one eight-wheeled. The former will be equipped with two motors of 10 h. p. each, and the latter with two motors each of 15 h. p. They are expected to be entirely noiseless in running. Until the Lehigh Avenue company erects a depot of its own it will have the use of the Traction company's depot on Lehigh avenue, between Front and 2d streets, where engines and dynamos will be erected for the charging of the batteries of the cars. The Lehigh Avenue road

will be, it is stated, the only line in America operated entirely by storage battery cars. Mr. William Wharton, Jr., to whom has been entrusted the whole management and details of the building of the new road, says: "The only difficulty heretofore experienced in running electric cars successfully has been that of expense. This we have entirely overcome by making a contract for a series of years by which the storage batteries needed will be kept in constant good order by renewal or otherwise, for a moderate fixed sum." The capital stock of the road is $200,000. The officers of the company are: president, Joseph T. Bunting; secretary and treasurer, J. McK. Barron. The principal stockholders are, William Rotch Wister, William Wharton, Jr., Langhorne Wister, W. L. Elkins, P. A. B. Widener, James R. Booth, Charles W. Wharton, John Wister, J. Morris Harding.

The subject of removing the poles and wires from the streets of the city, came up for consideration before a sub-committee of the Committee of Councils on Law, a few days ago, to whom had been referred the resolution offered in select council, "directing the director of public safety to notify several telegraph, telephone and electric light companies to remove all the poles and wires from the streets in the built up portion of the city by the first day of October, 1889." There were present a number of representatives of the various companies, including superintendent William R. Gill, of the Western Union company; A. J. De Camp, of the Brush Electric Light Co.; C. C. Adams, of the Postal Telegraph and Cable Co., and Dr. S. M. Plush, manager of the Bell Telephone company. Chairman Anderson explained that the matter had been referred to the committee to ascertain if it is practical to have the wires placed underground by the time specified, and if not, what time would be required to do the work. Superintendent Gill, of the Western Union company, said that it would be a physical impossibility to place all the wires underground in the time stated. "There are 10,334 poles in the City of Philadelphia, of which the city owns 4,000, while the balance are owned by the different telegraph, telephone and electric light companies. The Western Union company owns less than 1,200.

"There is a disposition among the different companies, and especially with the Western company," continued Mr. Gill, "to place the wires underground. I say here, by the authority of our company, that they are willing to enter into an agreement that the poles and wires in the old city proper shall be placed underground within the time named in the ordinance, that is, five years from the time the general ordinance went into effect, about two years ago.

"We intend to occupy one or two of the conduits or ducts of the Bell Telephone company. If we have no such right, then councils will be asked to repeal such portions of the Bell Telephone ordinance so as to enable us to place our wires in the conduits."

Dr. S. M. Plush, of the Bell Telephone company, stated that the wires placed underground up to the present time were merely experimental, and that there was no known cable at the present time which would last over three years. He said that lines were placed underground in Chicago at considerable expense, but very little had been accomplished from their use.

Mr. Gill, who also represents the Philadelphia Local Telegraph Co., said that the wires of that company were stretched mostly across house-tops, and that very few poles were used. In answer to an inquiry, Mr. Gill said that all the Western Union wires were attached to poles, none being stretched across the house-tops.

Mr. A. J. De Camp, of the Brush company, stated that his company occupied 475 poles in the city. He said that the original ordinance of the Brush company gave them the right to lay their wires either underground or overhead, and the company have never lost sight of the fact that the wires will go underground when a system is found to be effective. "Ever since the passage of our ordinance we have kept up experiments for an underground system, but up to the present time we have never been able to find any practical system for arc lights. If the idea is abroad that the electric light companies have done nothing towards securing a good underground system, that is a mistake. We have over $200,000 worth of property in the streets of Philadelphia, which councils can destroy, but we didn't believe the city intended to do anything of the kind. We have expended a large amount of money, experimenting for a good system, but thus far we have been unable to find it, but it may, and no doubt will come some day."

The Welsbach Incandescent Light company, of this city, in which a number of prominent Philadelphians are interested, not only as shareholders, but as officers, is winding up its affairs, and the work of returning subscribers their money, less a certain amount to cover working expenses, was begun a few days since. The directors of the company include such well-known names as Thomas Dolan, W. W. Gibbs, George Philler and Wm. M. Singerly. The amount per share paid in was $30, and the actual cost upon each share has been $1.53, so that $28.47 per share is returnable to stockholders. The capital, less expenses, has been held in trust by the First National Bank.

The stock of the Philadelphia Welsbach Incandescent Gas Light Co. was purchased under a subscription paper providing for a committee of nine to determine within one year whether the business of the company could be profitably conducted as purposed in the contract under which the patent rights were obtained, and providing also that all purchasers should be relieved of their holdings and be paid back all moneys expended by them in the purchase of stock, except the cost of the conduct of the business to such date, should the report of the said committee be adverse.

This committee, which consisted of Thomas Dolan, Henry C. Gibson, William T. Carter, Dr. Joseph S. Neff, W. F. Russell, A. G. Richey, William Wood, W. W. Gibbs and Randall Morgan, made this report:—

That they find that every reasonable effort has been made to place the burner on the market in numbers sufficient to earn a profit upon the capital stock of the company, which is $3,000,000 at par; and that, while a fair measure of success has been realized,—about 10,000 burners having been sold and installed,—yet the low pressure and unequal pressure of gas in Philadelphia has caused so many difficulties that they believe a long time must elapse before the business can be done on a scale sufficient to earn dividends on so large a capital stock.

The net expenses of the business to March 31, 1889, have been less than the estimate represented when the stock was purchased, amounting to only $1.53 a share, leaving a balance of $28.47 a share unexpended, which balance the committee recommend be paid to the purchasers of the stock of the Philadelphia company upon delivery by them duly assigned to the Pennsylvania company, of all stock so purchased.

This was a local company, and its liquidation does not directly affect either the parent company or the Welsbach Incandescent Gas Light Co., of Pennsylvania.

PHILADELPHIA, May 17, 1889.

BOSTON.

Electric Railway Matters.—The West End Street Railway Co. Granted the Privilege of Employing Overhead Conductors on all its Routes; the Company's Agreements with the Municipality.—Rapid Extension of the Electric System to be made by the West End Company.—The Beverly and Danvers Railway.—Captain Griffin's Lecture at the Massachusetts Institute of Technology.—The New England Telephone Co.—Mr. Thos. D. Lockwood Sails for Europe.

ELECTRIC street railways continue to be the chief topic of interest in electrical circles at Boston. On the 1st of May the aldermen unanimously adopted the following order and refused to reconsider it:—

Ordered, That consent and permission is hereby granted to the West End Street Railway Co., in addition to the rights now possessed by it, to establish, construct, maintain and use the overhead single trolley electric system of motive power, so called, in the operation of its cars in and on each and all of the streets, ways and squares of the City of Boston wherein and on which the tracks of said company are now located, and to construct, lay, maintain and use the poles, wires and appliances and such electrical appliances and apparatus, and to make the underground and surface alterations in and on said streets, ways and squares necessary for that purpose. All work of construction under this order, and all kinds and quality of material used and the height of all poles erected shall be satisfactory to the superintendent of streets and committee on paving. The poles shall be cylindrical in shape and painted before erected, and shall be removed when so directed by the board of aldermen, after 60 days' notice. No poles shall be erected under this order until a plan showing the location of the same has first been filed by said West End Street Railway Co. in the office of the superintendent of streets, and has been approved by him and said committee on paving. This order shall be null and void unless the same be accepted by said West End Street Railway Co. and notice of such acceptance filed with the city clerk within 30 days from the passage hereof.

The legality of the action of the aldermen in granting the franchise has been questioned. In section six of the new city charter it is stated that:—

The executive powers of said city, and all the executive powers now vested in the board of aldermen, as such, as surveyors of highways, county commissioners or otherwise, shall be and hereby are vested in the mayor, to be exercised through the several officers and boards of the city in their respective departments, under his general supervision and control.

Mr. Richardson, the corporation counsel, had his attention called to this subject in March last. On the 18th of that month he gave a written opinion in reply to a request from the board of aldermen. After citing all the authorities, he reached the conclusion "that the board of aldermen had the power to grant to said West End Railway Co. the right to locate electric overhead wires for the transmission of power for the purpose of running its cars in the streets named in their order therefor." This opinion applied to the location of wires on Cambridge and other streets. Mr. Richardson informs Mayor Hart that the order granting the company the right to use the overhead electric system in all the streets in the city is legal. It is somewhat remarkable that during all the hearings upon this subject our citizens have offered but little opposition, the opponents coming from the ranks of those who have personal interests to protect.

At a meeting of the common council on the 2d, inst., the following resolution was presented by councilman E. P. Barry, of ward 15:—

Resolved, That the common council deem that the action of the board of aldermen in granting exclusive rights to the West End railroad in the construction of the overhead system of electric wires for railways in this city is against public policy, a dangerous precedent, and can but result in intricate and alarming contests between the City of Boston and the West End Railroad Co.

The order was assigned to the next meeting.

Mayor Hart gave a hearing to police and fire commissioners and others in relation to the probable effect of the adoption of the proposed overhead electric system of the West End railroad upon the city's electrical apparatus, and had to consider the opposition

of the telephone companies and the storage battery interests, but at a late hour on the 10th inst, the mayor signed the order passed by the aldermen. Before the order was signed the following bond was signed by President Whitney, of the West End Street Railway Co.:—

Know all men by these presents, that the West End Street Railway Co., a corporation duly established by the laws of the Commonwealth of Massachusetts, is holden and stands firmly bound and obligated with the City of Boston, in the said commonwealth, in the full and just sum of $50,000, to be paid unto the said City of Boston or its assigns, to which payment, well and truly to be made, said West End Street Railway Co. binds itself in the sum above-named firmly by these presents.

Whereas, The West End Street Railway Co. aforesaid has, by an order of the board of aldermen of said city, passed on May 1, 1889, and approved by the mayor this day, obtained permission to establish, maintain and use the overhead single trolley electric system of motive power in the operation of its cars on its tracks located in certain streets in said city, as set forth in said order; and

Whereas, The City of Boston owns and maintains, in and over some of said streets certain electric signal and telephone wires, one used by the fire department of the city, commonly called "fire department telephone and telegraph system," and also one used by the board of police, commonly called the "police signal service," and it is suggested that the establishing, maintenance and use of the wires of and in said overhead single trolley electric system of motive power of said West End Street Railway Co. in said streets may impair the efficiency of the aforesaid wires owned and used by said departments of the city; and the said West End Street Railway Co. has agreed so to construct, maintain and use its said overhead single trolley electric system of motive power as not to impair the efficiency of said wires, systems or service of said fire department and board of police;

And it is suggested, among other things, that the putting underground by the said West End Street Railway Co. of its power or feed wire in its said overhead single trolley electric system will prevent or avoid many of the liabilities to injury and impairment of the efficiency of said wires of the said city, which might otherwise be caused by putting up said overhead single trolley electric system of wires of the obligor, and that putting guard wires over the trolley wire in certain places will also diminish or remove liability to injury of the said wires of the city.

Now, therefore, the condition of this obligation is such that if said West End Street Railway Co. shall, in addition to the conditions and terms set forth in said order, well and faithfully so construct, maintain and use its poles, wires and other apparatus in its said overhead single trolley electric system of motive power as not to impair the efficiency of the said wires owned and used by the said city, to wit, said "fire department, telephone and telegraph system," and the "police signal service," putting its said power or feed wire underground, or insulate it where it is above ground and exposed to the air, and making and putting up at its own expense a "metallic circuit" system, so called, for the said fire department if required; protecting all said wires of the said city so far as shall be required by it by guard wires over the electric trolley wire and feed wires of the obligor, and shall put up, maintain and use such other guards and protections to the said wires of the said city as may be necessary, and do all such other things from time to time as may be necessary, so that the practical efficiency of said wires of said city, to wit, the "fire department, telephone and telegraph system," and the "police signal service," shall not be impaired by the putting up, maintenance or use of said overhead single trolley electric system of motive power by the obligor, then this obligation is to be void, otherwise to remain in full force.

Mr. Whitney also signed the following agreement in behalf of the West End Street Railway Co.:—

In consideration of the permission of the board of aldermen of the City of Boston, dated May 1, 1889, and approved by the mayor this day, to the West End Street Railway Co., to establish, construct, maintain and use the overhead single trolley electric system of motive power in the operation of its cars in the streets of the City of Boston, as set forth in said order, and

Whereas, in the event of a fire it may be deemed necessary by the officers of the fire department of said city that, in order to better extinguish or prevent the spread of such fire, it may be necessary to cut the wire or wires of said West End Street Railway Co. authorized by said order;

Now, therefore, it is hereby understood and agreed that in such case the officers or men of said fire department may cut said wire or wires without any liability therefor on their part or on the part of said city to said West End Street Railway Co., and that the wire or wires so cut shall be repaired and restored by the said West End Street Railway Co. at its own expense and without expense or cost to said city.

In witness whereof the West End Street Railway Co. has hereunto set its hand and caused its corporate seal to be hereto affixed this tenth day of May, A. D. 1889.

Although the electric method of propelling street cars has been adopted in various cities, Boston will be the first large city in which such a motive power will supersede horses altogether.

Our city, therefore, will have the credit of testing this system on a far larger scale than any other place in the country. As New York has looked rather askance at it, so much the more praise will redound to us if our streets prove the arena in which the problem is solved of transporting millions upon millions of passengers yearly without any hideous L road encumbering and disfiguring our principal avenues.

The bill before the Legislature to authorize the incorporation of the Boston Elevated Railway Co. is the next thing to settle. It is idle to make a prediction as to the outcome; but with the West End Railway, the Thomson-Houston company, the Fifty Associates and other heavy real estate owners, and all the steam railroads arrayed against the bill, it will be almost a miracle if it escapes defeat. In speaking of this matter, it is interesting to note the difference of feeling between the Senate and the Boston board of aldermen on the one hand and the House and common council on the other. Both of the larger bodies named are openly hostile to the West End Railway and are ready and willing to do anything to thwart its progress, while the two smaller bodies, by a strange coincidence, are inclined to accede to its wishes with refreshing complacency. The bill which has just come from the Street Railway Committee prohibiting the use of overhead electric wires by street railways in cities of more than 60,000 inhabitants is evidently aimed at the West End, and it is worthy of remark that it is indorsed by two of the three senators on the committee, as well as by all but two of the representatives. When this matter came before the committee, it was claimed by the West End that it already possessed the right to construct overhead wires, and that it therefore did not ask for further legislation. The petitioners were representatives of other street railways, who asked for the same privileges which they conceded were already possessed by the West End. The upshot, therefore, is rather surprising, and either the committee have become convinced that the overhead wires are an element of danger or they are not unwilling to snub the West End Railway. Perhaps both considerations had more or less of weight in the making of their report. The Thomson-Houston company, mentioned above as being interested in the defeat of the elevated railway bill, has close relations with the West End company, and is credited with having invested $100,000 in the overhead system. If the elevated bill passes, some other electric company will be likely to provide the electric plant, should electricity be used as a motor—which, by the way, is not absolutely certain, as some of the parties in interest incline to the cable system.

President Whitney says that the West End Street Railway Co. will extend the electric system as rapidly as possible. At present he is not prepared to say in what streets the system will first be carried, although Roxbury will early receive attention, a line from Charlestown to Franklin Park being one of the most important projects. The work of laying double tracks from Arlington Centre to the Cambridge line is being vigorously carried on by the West End company. The new piece of road is to have overhead wires for electrical cars. It is expected that by June 1, the electric railway system will be complete between Boston and Arlington.

The Beverly and Danvers Electric Street Railway Co. has cleared the ledges upon the line to Danvers. It is reported that it will not use the overhead wire, but will use the storage battery system. Locations have been granted in Danvers and Beverly for the line.

The legislative committee on manufactures reported unanimously a bill to authorize the town of Danvers to provide its inhabitants with electric light and power. Power is given to the town to put in an electric plant at an expense of not over $15,000, and it may issue 30-year four per cent. bonds for that amount. The business is to be under the management of a board of electric light and power commissioners, to be elected at the annual town meetings. The net surplus is to be paid into the sinking fund. The acceptance of the act is conditioned upon a two-third's vote of the town. The town is to be supervised by the board of gas commissioners.

Captain Griffin, late of the United States engineers, general manager of the Thomson-Houston Electric Co., discussed the electric motor, in an interesting paper read at the Institute of Technology, April 25. He contended that the electric motor had exhibited its efficiency, economy, durability and reliability. He stated that it is well within limits to put the saving of electric over horse-power at 25 per cent. With regard to the danger from the use of electricity, Captain Griffin says that no man, woman or child has ever been killed, or even seriously injured by a 500-volt current, and that is the current for railway work. The danger limit is probably about 1,000 or 1,200 volts. The captain has developed into a full-fledged lecturer; he has made addresses at several of our clubs, and has a taking and popular style of elucidating the subject he handles with so much ease.

The New England Telephone and Telegraph Company's statement of the results of the first quarter of 1889 is as follows:—

	1889.	1888.	Increase.
Gross receipts	$299,505	$266,328	$33,177
Expenses	224,492	190,334	34,158
Net earnings	$75,013	75,994	*981
Construction	19,768	3,270	16,498
Surplus	$55,250	$72,724	*$17,474

* Decrease.

Mr. Thos. D. Lockwood, of the American Bell Telephone Co., sails from Montreal, Canada, on the 29th, for a two months' tour in Europe. He will make a study of telephone matters, especially in Great Britain, and visit the Paris Exposition.

BOSTON, May 16, 1889.

CHICAGO.

The Electric Club.—Extension of the City Lighting System.—No Progress with the Telephone Regulation Bill in the Illinois Legislature.—Changes in the Thomson-Houston Office at Chicago.—Electric Light Notes.

THE Chicago Electric Club is finally quartered in rooms which are a credit to the organization. The new quarters comprise two floors in the High building on Adams street. They are admirably adapted to the needs of the club situated as they are in a central location. The two floors are connected by a private stairway. The furniture and decorations are elegant, and the effect is strikingly in contrast to the old dingy quarters in which the club has been located for over a year and a half. The committees which

had in charge the work of arranging and furnishing the new rooms, have labored enthusiastically, and their efforts have been generously seconded by the majority of the members of the local electrical fraternity. They received larger donations of cash than they had anticipated, and the club will meet in rooms free from debt; in fact it will not be necessary to use the fund made by the assessment of the membership. The first meeting was held on May 15, with President Barton in the chair. He congratulated the club on its good fortune in securing such desirable quarters, and commented on the fact that the membership was rapidly increasing. It was decided to open the rooms formally by a reception, which will be held early in June. On that occasion members are expected to invite ladies to be present.

City Electrician Barrett has completed his plans for extending the Chicago city electric light plant, and work will commence about June 1. The system, as it has been stated before, will eventually embrace the entire city. The city has been divided into 11 districts and in each section a central station will be built. To complete this work will require at least three years, according to the city electrician's estimate. The work which it is expected will be completed this year, will cost from $300,000 to $350,000. Professor Barrett hopes to have from 700 to 1,000 lamps in operation on the streets of Chicago before January 1.

Mayor Cregier and a number of Chicago city officials, visited Springfield in the early part of the month to lend their assistance to those who were advocating the adoption of the bill which reduces telephone rates throughout the state. The new mayor does not favor the bill which confers on city councils the right to regulate telephone rates. The telephone bills have made no appreciable progress in the legislature, and it is generally assumed that they are hopelessly dead.

Daniel B. Steadman has retired from the Chicago office of the Thomson-Houston company and has returned to his old home in Boston. B. E. Sunny and John L. Martin will hereafter have charge of Mr. Steadman's department.

An extremely interesting electric light installation is that employed in illuminating the tunnels for the new water works system of Chicago. The plant consists of a United States dynamo and 75 incandescent lamps. The use of electric lights instead of lamps has been found extremely advantageous and it has greatly facilitated the work.

The Woodward Electrical Co., of Detroit, has installed on the Michigan Central railway a storage battery plant for train lighting. The coach was recently in Chicago on its first trip.

CHICAGO, May 20, 1889.

TORONTO.

Underground Wire Agitation.—An Exhibition by the Heisler Electric Light Co. at London, Ont.—Electric Light Notes.—Mr. H. S. Thornbery Establishes an Electrical Engineering Firm at Toronto.—A Branch of the American Electrical Works at Montreal.

THE underground question, such a bugbear to electrical people, will not down in Canada. Montreal, which city refused the Bell Telephone Co. privileges for underground work last season, is again agitating the question in connection with the opening of Craig street. It is safe to say, however, that no underground work will be done in Montreal for some time to come. In Toronto, the question is a live one. The Bell Telephone company the Toronto Electric Light Co., the Consumers' Gas Co. and the Edison company have petitioned the council to allow them to proceed with underground work. The sub-committee, to whom the matter was referred, reported in favor of giving all the companies except the gas company the privilege of proceeding. The gas company were refused on the ground of danger from the system they propose—the Westinghouse. The matter was referred back again to the committee by the council, and there the matter stands. It is probable the underground question will not be finally disposed of this year.

At London, Ont., the Heisler company have an exhibition plant, under permission of the council. The manager of the Great Northwest Telegraph Co. has notified the council they propose to hold the city responsible for any damage to their lines caused by the Heisler system. It is understood that the Heisler system runs under a very high pressure—several thousand volts.

The Ball Electric Light Co. are as alive in Toronto as they are in the States, and report as recent sales 400 incandescent lights in the Goodham & Wortz distillery, Toronto, and 350 incandescent lights for the Ontario government cottages for insane at Mimico, Ont.; also, 75 arcs at Victoria, B. C., and 40 arcs to the Belleville, Ont., Gas Co.

Among the recently established firms in the electrical line in Canada is that of Henry S. Thornbery & Co., electrical engineers, Toronto, who propose to do a general electrical and jobbing business. They were successful competitors for the electric light work on the new Board of Trade building, where 500 lights will be required.

The American Electric Works, of Providence, through the foresight of their genial manager, Mr. Eugene Phillips, have established a branch at Montreal, where they will manufacture a general line of wires and cables.

The Royal Electric Co., of Montreal, report as recent sales, 600 lights, alternating, to the Moncton, N. B., Gas and Water Co.; 200 lights, incandescent, for the residence of Hiram Walker, Caches Island, Ont.; 1,000 lights, alternating, to the Manitoba Electric and Gas Co., Winnipeg, Man.; also 40 arcs to the same company.

TORONTO, May 19, 1889.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall street, New York city.*

THE CONDENSER AS A COMPENSATOR.

[107.]—In your number of February, page 47, Mr. William Maver, Jr., states in his able article on condensers as follows: "It is safe to assume that there is *no* substitute for the condenser as a 'static compensator' in submarine cable duplex telegraphy, and no practically successful substitute for it in overland duplex telegraphy. * * * On these assumptions the money value of the condenser as a static compensator may be estimated at millions of dollars. The Baltimore and Ohio Telegraph Co. alone by the use of this instrument (the condenser) were (*sic*) enabled to operate many thousand miles of duplex and quadruplex circuits, which without it could not have been successfully accomplished."

For the information of your many readers I venture to say that Mr. Maver's assumption is not correct, inasmuch as the Bankers' and Merchants' Telegraph Co. successfully operated 12,000 miles of duplex circuits from March, 1884, to October, 1885, without giving to the artificial line a static capacity equal to that of the main line wire.

A commission composed of Henry Van Hoevenberg, Charles Cuttriss and Minor M. Davis, all well-known and competent electrical experts, have recently made a test of the Jones' Static Compensator on the Postal Telegraph-Cable Co.'s New York and Chicago Produce Exchange duplex wire (one of the fastest circuits in the country), 1,027 miles long, with repeaters at Olean, 400 miles from New York. The wire was entirely equipped with compensators, and tested for two weeks in wet and dry weather, and the commission reports as follows:—

NEW YORK, Feb. 14, 1889.

"The object of this device is to provide in the polar duplex an efficient compensation for the effects of the static discharge, to be used in place of, and for the same purpose as the Stearns' Condenser. Briefly, the instrumentalities used for this purpose consist of an induction coil, the primary circuit of which forms a part of the main line, the secondary circuit discharging into a separate coil on the receiving relay. This arrangement was examined working under various conditions of weather, and it was found to accomplish its purpose *effectively in every case.*"

I do not claim any originality for the idea of the compensator, the principle of which was clearly foreshadowed in Cromwell F. Varley's English patents, No. 1,318 of 1855, and No. 3,059 of 1856. The practical application to neutral and polar duplexed wires, and later to Edison's quadruplex, is the extent of my contribution to electrical progress in this particular. F. W. JONES.

ELECTRICAL ENERGY AND LIGHT.

[108.]—Apropos of the recent experiments of Professor Stone on electrical energy and light, I send you some struggles after the relations between these two physical conditions.

They were unsuccessful, that is, the results were negative—but sometimes I imagined that I did observe a slight change in the intensity of sound in the telephone. They will illustrate some of the gropings after the truth which are now going on. I copy from my laboratory note book for 1884.

Experiment 1 was a repetition of Faraday's experiment of the rotation of the plane of polarization of light by magnetism.

Experiment 2.—The analyzer was removed; a piece of unannealed glass was wound with fine insulated wire; the wire was connected with a Bell receiver. The glass having been placed in front of the polarizer the latter was made to rotate rapidly on its axis. No sound was heard in the telephone.

Experiment 3.—The polarizer was fixed; the glass and telephone were allowed to remain as in experiment 2. A cardboard disc, perforated with a series of holes arranged in a circle, attached to a rotator, was made to rotate with various velocities in the path of the light entering the polarizer. The light was thus

divided into a great number of parts. No sound was heard in the telephone.

Experiment 4.—The siren was removed, everything else remaining the same. The glass was subjected to pressure with a screw. When it was alternately compressed and released from pressure no sound was heard in the telephone.

Experiment 5 was the same as 4, except that the glass was permanently compressed and suddenly passed through the beam of light.

Experiment 6.—The preceding experiments were all repeated with two telephones in circuit, opposite one of which a tuning-fork was placed. No change was noticed in the intensity of sound.

Experiment 7.—A Hughes' sonometer was introduced in a microphone circuit. The glass and other bodies surrounded by their coils were placed singly in the microphone circuit. The telephone failed to show any change in the ticking of the watch on the microphone stand when all the previous experiments were repeated.

Experiment 8.—A Hughes' induction balance was placed in circuit. All the previous experiments were reproduced with similar results.

Many variations were made in the length and diameter of the wire. The material was changed. Pressure was applied transversely and longitudinally. A soft iron core was also placed in the coil of wire.

When the microphone was placed in circuit, it was found necessary to remove the watch and substitute an electric vibroscope. The battery was also changed to get rid of variations in strength of current. The "frying" noise of the microphone was obviated by changing the form of the instrument, so that a smooth sound of constant intensity was heard.

J. W. MOORE.

Lafayette College, Easton, Pa., May 9, 1889.

LITERATURE.

The Theory and Practice of Absolute Measurements in Electricity and Magnetism. By ANDREW GRAY. London and New York: MCMILLAN & CO., 1888. In two volumes. Vol. I.

THE point of view from which a work of this character, dealing as it does with both the theoretical and practical sides of its subject, is examined, must have an important influence upon the nature of the criticism to which it is subjected. Comment is often made upon fact that the close application of American electricians to the commercial work in which they are generally engaged leaves them comparatively little leisure to devote to speculative hypotheses, particularly those involving the use of the higher mathematics, with which they are much less familiar than their European contemporaries. It seems not unlikely, therefore, that if viewed solely from our practical standpoint the work of a professional scholar, like Professor Gray, might appear to be a trifle too abstract and complex for general utility. On the other hand, in the case of a work which of necessity has a direct practical bearing, and, indeed, relates largely to manipulative processes, to consider it wholly as a theoretical treatise would be equally unsatisfactory; so that it is necessary to take into account both aspects of the subject.

It seems fair to presume that technical books of this class are written for the instruction and education of persons who propose to make practical use of the information derived from them; and this being true, the simplicity, utility and convenience of the methods adopted for imparting such information are certainly legitimate subjects for criticism. While no one will deny the immense influence which the application of higher mathematics to the expansion of electrical laws has exerted to increase our knowledge of electricity and our ability to utilize it to the greatest advantage, many practical teachers are now convinced that the experimental method is superior wherever applicable. Faraday was pre-eminently an observer and experimenter, and yet his work will always remain the foundation for mathematical theories as well as practical electro-technics. Even Maxwell, who elaborated the most profound mathematical theories relating to electric and magnetic phenomena, only shortly before his death announced his belief in the superiority of methods of treatment of the subject akin to those of Faraday.

The work before us is essentially a mathematical treatise dealing with all but the more abstract parts of electrical theory as related to precise measurements, but stopping far short, with a few exceptions, of anything like practical minutiæ. The general design of the work is thus to weld together, as it were, the practice of absolute measurements and the mathematical theory of electric and magnetic phenomena, and the author has so clearly defined this intention in his preface that no one who reads that introduction need be misled as to the scope of the work. Volume I. opens with a discussion of the theory of electrostatics and flow of electricity, occupying nearly one-third of the volume, and contains chapters on units, general physical measurements, electrometers, comparison of resistances, comparison of capacities and measurement of specific inductive capacities. The phenomena observed by Coulomb, Cavendish and Faraday are, of course, the foundation for the elaborate electrostatic theory treated of in the first chapter, which also includes a consideration of the more complicated theorems of Green and Maxwell. The mathematical treatment of this portion of the work is perhaps as simple as it well can be on the basis chosen, but necessitates an easy familiarity with the calculus. The definitions are not, however, always so lucid as they might be, as, for example, the following selected at random: "The electric volume density at any point in space is the limit toward which the ratio of the quantity of electricity contained within an element of space including the point to the volume of the element approaches as the element is taken smaller and smaller."

It is doubtful whether the order in which the subject-matter is arranged in this book, is the most simple and convenient that could have been selected, and whether it is advantageous to so subordinate the experimental to the mathematical treatment of the subject, as Professor Gray has evidently done. While no well defined distinction can be made between electricity at rest and in motion, the phenomena attending the action of current electricity are so much more readily observed and measured than those resulting from statically electrified bodies, that we are led to question the advisability of investigating the latter phenomena first in order, although the chronology of the discovery of electrical laws appears to favor this method. True, a sound understanding of the electrostatic theory clears the path for the study of magnetic and electro-magnetic phenomena, but we think the study of the whole subject would be simplified and facilitated by reversing the common order of procedure, as adopted by Professor Gray.

We have no fault to find with the treatment of the theory of electricity from a mathematical standpoint, from which only it can be generally considered, nor with the able manner in which the subject is presented, but we are surprised that a work devoted to the elucidation of experimental measurements should give so little attention to those practical demonstrations which so effectually impress the student's mind. While in strictly theoretical treatises like Maxwell's and Thomson's, where familiarity with all phases of electrical phenomena is demanded of the student, experimental methods are not, of course, expected, such methods would certainly not be out of place in this book. The subject of absolute measurements is one, however, in which a great many practical men whose time, and perhaps capacity for mathematical speculations, is limited, are interested, and who look to a book of this character to supply them with the desired information in a simpler form than it is to be found in the higher mathematical treatises. The author's smaller work, of which the present one is said to be an expansion, went far toward fulfilling these requirements and met with a large demand in this country. With the exception of this general criticism there is hardly anything but praise to be bestowed upon this excellent treatise.

The theory of the flow of electricity is considered in the second chapter, and its attendant effects in relation to electromotive force and resistance are scientifically defined in a somewhat novel manner. The hydro-kinetic analogy of an electric current, and the analogy of electrical to thermal conductivity are referred to briefly, and numerous formulas and theorems relating to the steady and variable flow of electricity in various networks of conductors are discussed at some length. The electromotive force of voltaic cells and the arrangement of batteries for maximum current and efficiency are incidentally touched upon in this chapter, which concludes with an elaborate consideration of the transmission of electrical waves along a conductor, embracing cables and other special cases.

Perhaps the most commendable chapters in this first volume and certainly the ones which will be oftenest referred to, are the third and fourth, relating respectively to units and dimensions, and general physical measurements. The former describes with much fullness the origin of the various fundamental units and the methods of defining and producing the standards, and effectively shows the relation between the absolute and derived units, and between the practical standards adopted by the French and English governments. The subject of units has been discussed to great extent in many electrical text books, but in none that we have in mind has it been given the careful and thorough treatment which it receives here. The fourth chapter deals in the same thorough manner with the various physical measurements which are of necessity closely identified with the measurement of electrical quantities. Whoever has manipulated electrical apparatus in connection with painstaking tests of any character, is acquainted with the numerous corrections which have to be made at almost every step for inherent inaccuracy or physical changes in the instruments employed, and with the difficulty experienced in putting one's hand on just the correction required. Much information on points of this character is accessible in a convenient form in this chapter. The measurement of angular deflections by vernier, projection and telescope, observations of period and amplitude of oscillations, measurement of couples,

torsional rigidity and inertia, together with temperature and other corrections in connection therewith are treated in considerable detail. An instructive discussion of the theory of unifilar and bifilar suspensions concludes this valuable portion of the work.

The next chapter is devoted to the subject of electrometers, their theory and practical forms and modes of operating being very fully described. A perusal of this chapter particularly impresses the reader with the fact that the labors of Sir William Thomson permeate and almost engross every part of the theory and practice of this branch of electro-technics. The comparison of resistances receives the attention which its importance demands in the next chapter, in which upwards of one hundred pages are devoted to it. The chapter opens with a statement of Oersted's discovery of the foundation principle of the galvanometer, as explained by Ampere's electro-magnetic theory, and after showing how this instrument can be adapted to the detection and comparison of electric currents, describes the various forms in which resistance coils may be practically constructed. The different slide wire and meter bridges and many of the more complicated methods of measuring resistance, not commonly included in text books, are described with much completeness, and the descriptions include most of the accurate methods of measuring both very high and very low resistances. Considerable space is also devoted to the measurement of the resistance of electrolytes and the internal resistance of batteries. The topics of this chapter have been treated somewhat more practically than other portions of the book, and the guidance supplied will, no doubt, be highly appreciated by many readers. Portions of this chapter, treating of the sensibility of galvanometer and bridge methods, and of the calibration of a wire, are particularly full and useful.

The concluding portion of the first volume describes the various methods of comparing capacities and measuring specific inductive capacities, embracing considerable matter previously to be found only in the proceedings of foreign scientific bodies. Numerous experiments relating to this subject, from Faraday's time down to the recent experiments of Hopkinson and Ayrton and Perry, are freely described and much valuable information is condensed in a limited space. Tables of units, resistances and useful constants are added at the end of the volume.

It is announced that Volume II. will contain an account of magnetic theory, units and measurements; electro-magnetic theory and absolute measurements of currents, potentials and electrical energy; the definitions and realizations of the ohm and other units, etc.

CATALOGUES AND PAMPHLETS RECEIVED.

Electrical Condensers, William Marshall. It is a pleasure to receive Mr. Marshall's pamphlet circular containing a list of ordinary and standard condensers, manufactured and supplied by him. It is a pleasure because he took up a difficult branch of electrical work, and through patient and persistent effort, doing nearly all his work with his own hands, achieved complete success. His condensers have now for some years been held in high esteem by the electricians of telegraph and telephone companies for their reliability and durability, and they are very generally employed on duplex and quadruplex circuits. Not content with the success of his ordinary working condensers, Mr. Marshall essayed to produce trustworthy standard condensers for testing and laboratory use. He was not less successful in this more difficult task, and now produces standards that are found entirely satisfactory by responsible electricians, and fully up to the best European instruments in accuracy of adjustment and in insulation. Mr. Marshall is to be congratulated upon the repute attained by his products. The catalogue before us embraces a variety of condensers for different uses, and a line of resistance coils as well. It is accompanied by many testimonials from electricians who have used Mr. Marshall's condensers.

NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

ANNUAL MEETING, MAY 21-22, 1889.

TUESDAY EVENING, MAY 21.

THE fifth annual meeting of the American Institute of Electrical Engineers for the election of officers and the transaction of other business was held at the house of the American Society of Civil Engineers, May 21. The secretary read the annual report of the council as follows :—

REPORT OF COUNCIL FOR THE YEAR ENDING MAY 20TH, 1889.

Since the organization of the Institute, in May 1884, four yearly reports have been presented at the annual meetings which have been devoted to brief reviews of the work done by the society, with suggestions as to the proper course to be pursued in order to secure the greatest possible benefit to the members. By persistently keeping this object in view, the council has been enabled to secure the hearty support of electrical engineers both at home and abroad. This has permitted our officers to carry out the plans outlined in previous reports, so that it may be safely asserted that no similar organization in the world has made so full returns to its members in proportion to the subscription exacted for its maintenance.

As is now well understood it has become the custom to hold special meetings monthly for the discussion of professional papers. These meetings have been well attended and have done much to promote good fellowship among the members, while the transactions have been of exceedingly great value to electrical interests generally, and have been extensively copied by electrical journals in Europe as well as in America.

The reporting, printing and circulation of these transactions has entailed considerable expense, while the increase of business in connection therewith and the continual growth of membership has necessitated the establishment of permanent executive offices, which have been occupied by the secretary during the past year. The head-quarters thus established being conveniently located have been utilized for council and committee meetings, while the files of periodicals and transactions have been found of increasing importance to members. It became necessary at the expiration of the lease of these offices on May 1st, 1889, to change the location, and consequently more desirable quarters were secured on another floor of the same building, known as Temple Court, at a slight increase in rent. This could not well be avoided, and with the accumulation of books and papers, it will probably be necessary every year to occupy additional space. As, however, the continual growth of the Institute seems assured, so long as a progressive policy is pursued, it does not seem probable that any increase in dues will be necessary. The expenses during the past year have exceeded the cash receipts by $841.85, owing to delay in the payment of dues, a practice in which there has been a gradual reform during the past three years. The amount outstanding and believed to be collectable is $412.04. Both receipts and expenses have exceeded the estimates of your secretary made at the beginning of the fiscal year, for the reason that the business has undergone such a decided change that it was difficult to determine the exact results. Experience has shown that within certain limits, it is wise to pursue a liberal policy in issuing the Transactions of the Institute in such a form as will reflect credit upon the society as a progressive scientific body.

The gradual change which has taken place in the membership of the Institute is exceedingly instructive, and shows how perfectly its affairs have been conducted upon the lines laid down by its founders. Its gradual attainment of a recognized scientific standing, has been accomplished through the intelligent labors of its members, as shown in the improvement in the standard of its papers and discussions. While its growth in membership during the past two years has been most gratifying, it has lost the support of a few who have either failed to appreciate its work, or who consider that other associations come nearer to their ideal of an electrical organization. To make the situation more perfectly understood, it may be stated that out of the original membership of the Institute, not more than one-half were in perfect harmony with the proposed line of work, as no record existed by which its exact mission could be predicted. To-day, however, every person who proposes to join, may ascertain from examination of the printed Transactions of the Institute, whether he is likely to appreciate his membership. The result has been that the *personnel* of the Institute has undergone a gradual but decisive change for the better, and from a straggling membership of 260, two years ago, out of which barely 100 could be depended upon to give their financial support to the Institute, we have now a membership of 350, who may be relied upon to continue upon the rolls, and this number is increasing at the average rate of five per month.

No definite progress has been made during the past year in the movement for securing a permanent home for the Institute. The committee appointed for that duty has consulted with the committees and officers of other societies which are confronted with the same problem, and while the project is by no means neglected, it will not be permitted to stand in the way of the more important work of the Institute.

There have been 69 associate members elected during the past year, 63 of whom have qualified by paying their entrance fee and annual dues. Eight have resigned, and one member, George May Phelps, has died. The total number of members and associates on the secretary's book is 383, of whom 305 have paid their dues in full at the date of this report, being 38 more than at the same date last year. Thirty-one are now in arrears for one year, four for two years, 10 for three years, and 32 for four years. No transactions are sent to those who have fallen in arrears over one year, but as there have been several cases during the past two years where changes in circumstances have permitted the payment of back dues, they are not considered altogether hopeless. The amount collected from the delinquent list during the year was $119.84.

Eleven council meetings have been held during the year, and seven special meetings of the Institute, the transactions of which have been duly reported.

Respectfully submitted by direction of council.

R. W. POPE, *Secretary.*

The following financial report of the secretary was also read :—

SECRETARY'S BALANCE SHEET FOR THE YEAR ENDING MAY 20TH, 1889.

Ralph W. Pope, Secretary, in Account with the American Institute of Electrical Engineers.

Dr.

1889.	
To balance from 1888	126.92
Receipts for past year.	
Entrance fees	$ 815.00
Dues for 1885–6	10.00
Dues for 1886–7	25.00
Dues for 1887–8	84.84
Dues for 1888–9	2,676.86
Transactions sold	105.55
Electrotypes sold	186.92
Rent	266.71
Binding	74.58
	$3,871.83

Cr.

By cash to treasurer	3,827.51
Balance on hand	44.32
	$3,871.83

EXPENSES OF THE YEAR.

The treasurer has disbursed, upon warrants drawn by the secretary, the amount of $4,086.76, which has been expended as follows:—

Stenography and typewriting	$ 86.42
Stationery and miscellaneous printing	119.39
Postage	244.41
Messenger service	22.34
Collation	66.00
Secretary's salary	1,200.00
Engraving and electrotypes	244.02
Meeting expenses	30.35
Rent	563.37
Printing transactions	1,251.88
Express	7.95
Moving and cartage	2.00
Telegrams	.25
Gas	3.62
Ice	12.57
Binding	36.05
Office furniture and fittings	196.14
	$4,086.76

The following officers were elected for the ensuing year:—

President—Professor Elihu Thomson, of Lynn, Mass.

Vice-Presidents—Edward Weston, Newark, N. J.; Professor E. L. Nichols, of Ithaca, N. Y.; Major O. E. Michaelis, U. S. A., of Augusta, Me.; Dr. Louis Duncan, of Baltimore.

Managers—Dr. F. Benedict Herzog, H. C. Townsend, Henry Van Hoevenbergh, of New York; and Professor Wm. E. Geyer, of Hoboken.

Secretary—Ralph W. Pope, of New York.

Treasurer—George M. Phelps, of New York.

The above-named officers, in addition to the vice-presidents and managers holding over under the rules, will form the board of management until the next annual meeting.

Mr. Edward Weston, the retiring president, made the following address:—

THE RETIRING PRESIDENT'S ADDRESS.

Gentlemen: While I have been nominally president for a year, I must say that the burden of the work has fallen mainly on the vice-presidents, and particularly on Mr. Martin. He has done an amount of work for the Institute that only those who have been indolent, like myself, can appreciate. The year's work has been done almost entirely by the council outside of myself, for I have not been able to attend more than few of the meetings. In fact, when I was waited upon by Mr. Martin and several other gentlemen, before my election, I felt some delicacy about assuming the position, for the simple reason that I did not feel that I could properly perform the duties. I feel that I have lived up to that at any rate—I have failed properly to perform the duties. But the growth of the society is really encouraging. The work of the members has chiefly contributed to the success of this society. It is not any individual, but the members. The retiring vice-president has given an immense amount of time to it. He seems to like work, and when you have a willing horse you generally drive him freely. Mr. Pope, the secretary, has also done a very large amount of work.

A word in regard to amendment of the constitution. The constitution, with few exceptions, has worked well. It is wise to consider carefully the matter before making any radical changes. Some remarks have been made in regard to the position of foreign and resident members and also non-resident members. Now I take it for granted that the Institute to-day is not in the position in which it will be ten years from the present time. There are not many fine collections of electrical engineering books; and when I say electrical engineering, of course I do not mean to confine myself strictly to electrical science, but to the vast amount of literature that is necessarily connected with it. No electrical library, no electrical engineer's society's library would be complete without a very complete mechanical engineering library, and such a thing is very difficult to get. It is very costly. Here we have the civil engineer's part, and at the mechanical engineers' they have the mechanical part; but to get a complete library would mean an expenditure of a very large amount of money. The literature of the subject becomes more and more important every year, and the desire of having a library where the members of this society can either immediately refer to the books, or get them from the library and use them, will become more and more important. The advantages, therefore, it seems to me, of the society to-day for non-resident and resident members is a very different thing from what it will be ten years from now. Therefore, in making any changes in that direction, it would be wise, it seems to me, to consider that feature of it. All members of this society, assuming that it has a library, who are residents of the United States, could certainly very readily obtain books out of the library by express or otherwise, and they would be controlled by the laws of this country. They would have the privileges of the society so far, therefore, as the library is concerned. But foreign members could not very well do so, and would not need to do so, because they depend upon their own libraries.

The annual meetings of the Society of Mechanical Engineers are very largely attended. Most of the mechanical engineers of the country try to get there, and there is one very good feature about their meetings, and I think that this society will probably adopt it after a time, and that is, they do not confine themselves to one particular place. They are very much like the American Association for the Advancement of Science. From year to year they select a place, and members who cannot attend one year certainly can the next. Furthermore, the members who are in the locality selected are very willing always to show what developments have taken place in their vicinity. Now that would be a very wise thing for the electrical engineers to do. Instead of having an annual meeting in one fixed place, it would be well to have the meetings migratory. You would then get the benefit of an inspection of interesting electrical work in various districts. That would be more particularly useful in regard to the transmission of power and the designing and erection of stations. It would be desirable to consider very carefully this suggestion before you seriously propose to revise the rules. The question of raising the standard for admission has been thought of. We must not forget that this is a young institution. It is very young; and in the early stages of institutions of this kind a great many undesirable members will get in. You cannot very well prevent it. The weeding out process goes on, and it goes on quite naturally. The members that are not very useful will very frequently drop out of their own accord. This society has the best talent in this country in its ranks to-day. There is not a man, I think, of any standing in the electrical profession who is not a member. That is saying a good deal. Now, we have some who do not stand very high; but no man who stands well feels that he ought to be out of this society. I cannot recall a single instance where a man of any marked distinction has not his name upon the list as an electrical engineer. Of course there are gentlemen of distinction who are not electrical engineers, strictly speaking, and who are not our members, whom we should be very glad to have here. Sometimes there are three grades of membership in similar societies—associates, full members, and fellows. That plan works well in some societies, but it has caused a great deal of friction in others; and as to whether it is wise to consider it in this Institute can be left to the committee on revision. As it seems to me, the standard of membership has certainly been very much raised during the last two or three years. The rules now governing the admission to membership are certainly very good. Every man entering the society, no matter what his position in art or science, has to enter as an associate. If he desire to become a full member, he can file at the time of application a request for full membership. The council refers such request to a special committee whose members are not in the council. That committee passes upon his qualifications before he can be advanced to full membership, recommending to the council whatever course they deem best under the circumstances. That is an element of safety for which the late Mr. Shelbourne, who, I believe, drew these rules, deserved a great deal of credit. It has worked admirably.

It has been suggested to increase the number of managers. That has advantages and disadvantages. It seems to be largely a matter of proportion. If you increase the number of managers, then, in order that the affairs of the society shall be in the hands of a certain number of its managers, it will be necessary to establish a certain number as a quorum; and if you increase the number of managers, you ought to increase the number necessary for a quorum. Now, the proper way to get over that difficulty, it seems to me, is for the managers who have served not to desire to serve too often. That is a matter that also sometimes gives rise to difficulties in societies. Rotation in office I believe to be a *sine qua non* of success. If you do not have it you become fossilized, or you get running in a rut and you cannot get out of it. If it is difficult now to get a quorum of council, then increasing the number of managers will make it easier, provided the number necessary for a quorum be not increased. But that, I do not think, has been a serious difficulty in the past, there has nearly always been a quorum. The future of the Institute depends upon the exertions of its members to make it worthy of the name—the

Electrical Institute of America. A great many men now are laboring under strain of the worst kind. They have not the time to present their best thoughts here. The struggle for supremacy in certain parts of electrical work is something enormous. The amount of work that has been done, and of which not a word has been said, is also something enormous. That state of things will not last very much longer. The commercial conditions that now exist in the greatest field that we have to deal with to-day—transmission of power and the distribution of light—will very materially change, and there will not be such sharp competition commercially, or such keen struggle as there has been in the past; that is to say it will not fall upon us so heavily at any rate, it will be distributed over a larger number of laborers. Now that will certainly give us a chance to hear a great many more valuable papers. I know there are gentlemen present here now who have done a great deal of original work, and who do not get up here. That is mainly due to the fact that those men have to work very hard, and they do not get as much time for the relaxations of life as is necessary. No body of men in the country, I think, has worked harder than electrical engineers during the last ten or twelve years, and the strain cannot be kept up indefinitely; we must have a radical modification. When that change comes we shall have a change in the society also for the better. We shall have more valuable thoughts presented to us. That is what we want to encourage. In connection with the growth of the electrical industries in this country, of course there has naturally been a good deal of jealousy. That is absolutely unavoidable; we are not all perfect yet. The petty jealousies in the electric light field have been very much against the introduction of the electric light and against its growth. It has not aided, but it has retarded the development of the art, and I do not think it has benefited any of us. I am glad to see that a great deal of it is disappearing. The very fact that we have such a society as we have here to-night, and that we have such papers as are to be read here, indicates that those difficulties are disappearing from the field. It should be the duty of every member—and I can give this advice because I have not followed it—it should be the duty of every member to endeavor to get: first, one other good member; and secondly, to make that good member do some work that will advance the interests of the society. I think the rules will take care of the rest of it, if you will only do that.

In conclusion, I have to say, that I am very grateful to you for the honor bestowed upon me at the last annual election, and I am sorry I could not do the office the justice I ought to have done it, and I have only to say that we have to-night with us Professor Thomson, who will succeed me, and who, I believe, will reflect much greater credit on the society than I have. I will appoint as a committee to escort the newly elected president to the chair Captain Michaelis and Mr. Martin.

THE NEW PRESIDENT'S ADDRESS.

Professor Thomson, on taking the chair, said—*Gentlemen of the Institute:* I sincerely appreciate the honor which you have conferred upon me, although I feel also, as Mr. Weston has no doubt felt, that a good deal of the work of the office will have to fall upon other shoulders than on my own. I unfortunately happen to be located at so great a distance, and am so busy, that it is impossible, even though I earnestly desire it, to get away to attend all the meetings of the Institute.

The remarks of our honored retiring president, Mr. Weston, match my thoughts exactly. He has gone over considerable ground which I have gone over in my own mind. It is certainly very gratifying to find the Institute growing and prospering as it is. I can look back several years, when its membership was much less, and the interest seems to have kept pace with the growth of the membership. I think we can say without the slightest hesitation that to-day the Institute is a much stronger institution than any of us expected it would become in so short a time; the whole profession is so new, it practically dates back only a few years. We had, of course, electrical engineers, whose duty it was to attend to the engineering work of telegraphs; but to-day the meaning of electrical engineering is much enlarged, our field is vastly broadened. We find that electricity comes into use in channels which we, none of us, looked to years ago.

The points touched upon by our retiring president in regard to a library I fully appreciate. I think that we should have at least the beginning of it as soon as possible. It is an enormous task to get what we really ought to have. That I thoroughly appreciate also, but I see no chance of having anything at all unless we make a beginning.

I would say also that I second his remarks in regard to the work that each member should do. A good deal of the work of the Institute has undoubtedly thus far fallen upon few shoulders, and we should like to see the members generally add something to the proceedings of the meeting. Everyone must have some experience—something that he can tell that will be of interest. Those who have worked in the field from the early start have undoubtedly, as Mr. Weston says, reasons, in some cases business reasons, for withholding information. I may say that that time is rapidly passing away. The conditions which have given rise to that state of things are rapidly passing away. The commercial aspect is always a little at war with the scientific and the truly liberal spirit, but I think the time is coming now when we shall look at things from a broader basis, and can do more work of a thoroughly scientific nature. Very great interest has been of late directed to the purely theoretical side of electricity. It seems as though we were getting a little nearer to that side, and, of course, though the business of an electrical engineer is largely connected with the commercial side, yet he cannot fail, if he represents his profession, to be interested in any theoretical advances which may be made; and it is to be hoped, indeed, that every new discovery, no matter whether it has any practical importance at the time, may be welcomed in exactly the same way as though it had an enormous practical importance. I think we are on the eve of further advances; we do not know what one year may bring forth. We seem to go up to a certain point, get a certain perfection, give certain laws, and then something else comes which starts a new line of research. Whether or not this process will go on forever we cannot say, but it looks as though we would have every opportunity of seeing it progress for many years to come. New facts are constantly coming up, and no doubt some of them will be utilized in unforeseen ways.

I reiterate my hearty thanks for the honor you have conferred upon me.

GENERAL MEETING—WEDNESDAY MAY, 22.

The meeting was called to order at 10 o'clock Wednesday morning by President Thomson, at the house of the American Society of Civil Engineers.

Mr. Alexander S. Brown read a paper entitled "Some Results with Secondary Batteries in Train Lighting."

Mr. Brown gave an interesting account of experience on trains of the Pennsylvania railroad, which was followed by a suggestive discussion. Mr. Brown's paper, together with several others which are omitted from this issue of THE ELECTRICAL ENGINEER, will appear in the July number, together with the discussions upon them.

The President—We have with us Dr. Duncan, and he will give us a paper on "The Inherent Defects of Lead Secondary Batteries,"—a subject which cannot fail to be of great interest.

Dr. Louis Duncan then read his paper. (See p. 264.)

DISCUSSION.

The President—I am sure we have all listened with great attention to this paper of Dr. Duncan's, as it brings forth a number of points in relation to the storage battery which I do not think have hitherto been given the prominence which they deserve, particularly the point of the existence of eddy currents due to the difference of chemical conditions in different parts of the plug; it also fixes the losses just where we would naturally expect to find them. There is one point I would ask information on. I understood Dr. Duncan to say that after the charging there was a continual and rather large loss—after the charging was completed——

Dr. Duncan—Not after the charge is completed and the current shut off, but when the action is simply the electrolysis of the solution——

The President—Possibly part of the loss may arise in the recombination in the solution of the ozonized oxygen with the free hydrogen, producing heat in the solution itself.

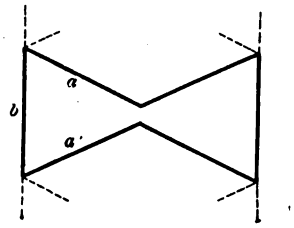
Professor E. P. Roberts—I would ask if it was a constant rate of charge or if the charge gradually tapered off as the battery filled. I was not quite sure when Dr. Duncan spoke of plates that merely had a face action instead of plugs, whether they heated more or less than when perforated plates were used.

The President—I understand the inquiry to be whether there was more loss of energy in the flat plate with the coating of active material laid over it than when the plugs were used?

Dr. Duncan—The discharge and charge rates were always the same. As for the flat plates I experimented on some which were made by depositing pure oxide on plain sheets of lead from a caustic solution of litharge. In that case with a very thin layer—about a quarter of an ounce to the square foot—of spongy lead and a corresponding amount of peroxide, the efficiency of the cell at a discharge rate which corresponded to that of the Julien cell—25 amperes for a surface of about 7 feet—I think, was about 90 per cent. But, of course, in that case the proportion of active material to total weight was very great. There was only a very thin layer and the distribution of chemical action was uniform and there was comparatively very little loss. A part of that 90 per cent. could be accounted for by the electrolysis of water.

As for the heating effect due to the electrolysis, I think Professor Thomson's suggestion is a very good one, but we did not attempt to find out what that heating effect was due to. It ought to be in about the same proportion, if the electromotive force is 2½ volts, then for one ampere-hour, the loss is 2½ watt hours. If the electrolysis itself takes up 1½ of the 2½ watt hours, then the other actions, whatever they might be, should give a loss of 1 watt hour to ½ watt-hours for electrolysis. I simply put that 1½ down to loss from heating effect. But it is probably due to the cause that Professor Thomson gave.

Mr. Townsend Wolcott—I understand Dr. Duncan to say that the chemical action of the plug begins at the surface of the plate. My experience indicates that with the ordinary form of plug (illustrating on the black-board), the grid being so much better a conductor than the active material, a new cell starts to form along *a*, *a'* first, and the last place that it is formed is the middle of the outside surface of the plug at *b*. Then it seems that as the



Plug of Active Material in Storage Battery Plate.

mass of the plug begins to form it becomes a still better conductor, and accelerates the action. The thing is to get that middle formed up as good as the other part. I think that is where a good deal of loss comes in—the difference between the amount of current the storage battery ought to give, and what it does give.

The President—On the point just mentioned, it would, of course, appear that the plug is not as good a conductor as it ought to be. If it were simply a very good conductor, then we would have an evening up at once, even though that evening might not take place from actual conduction of the current through the plug.

Mr. Wolcott—I think that emphasizes the point that Dr. Duncan mentioned in respect to a very thin film uniformly spread on a flat plate—that the action is equal all over. Of course, the current would come right straight out from the surface; there would be no spots.

Mr. Mailloux—In order to get the most out of a storage battery we want to charge it at such a rate that we shall get the maximum efficiency, so as to lose as little energy as possible in electrolytic work. On the other hand, the circumstances of its use dictate that the time expended in charging the battery should be as small as possible. Now, I think that it is possible to satisfy both requirements, because I have found that when a battery is discharged it will stand during the first period of charge a very high rate of charge without evolution of gas, and if the battery is watched it is possible to charge it in the minimum time, and also, probably, with as good efficiency as in any other way by always keeping the current at such a rate that it will be just below the point were it causes the evolution of gas. I have in this way made it a practice to begin charging batteries, whose normal rate of charge would be, say, 15 amperes, with 50 amperes, which could be kept up for an hour or two. Then it would have to be cut down to perhaps 30 for another hour; then 20, then 15, then perhaps to 10, then to 5, and sometimes I would finish with as low as 3. The battery was never allowed to evolve gas, and I think that that is the best way to treat the battery, because it gives the energy as fast as the active material can receive it. The condition which Mr. Prescott has called to our attention is a well-known one—namely, that the continued evolution of oxygen on a peroxide plate, after the battery is charged disintegrates the active matter, that it makes the peroxide into a fine granulated form, which is not coherent, so that it is not at all desirable—on the contrary, very undesirable—to prolong the evolution of gas. On the other hand it is quite desirable to charge that battery fully, so as to leave none of the matter unreduced, so to say. There is no way of doing it so as to meet satisfactory requirements but that of reducing the rate of charge towards the close of the charge.

Mr. G. B. Prescott, Jr.—I would like to ask Dr. Duncan if he took into account the difference in the internal resistance of the cells owing to the different state of charge or discharge in order to calculate the dual effect, and whether he took a mean of a few extreme readings or whether it was determined at uniform intervals.

Dr. Duncan—It was determined every five or six minutes, and the effect was calculated at corresponding times. The resistance for full discharge was sometimes five times as great as it was for fully charged plates.

Professor E. L. Nichols—I wish to emphasize what seems to me the importance of the point brought out by Mr. Mailloux a moment ago, and the importance of the experiments such as Dr. Duncan has described in the study of the storage battery. It seems to me that this is the only way in which this great number of perplexing questions that have arisen can be satisfactorily answered, and I think the sort of experiments described in this paper, made patiently and persistently, will finally give us complete control of this matter. This question of time is, of course, a very important one in the matter of charging. It would seem perfectly practicable to determine a rate of reducing the charge which should give the proper charge to a battery with the minimum time, never at any time giving it more than it can safely take. However, I think that this has more to do with the economic question than it has with the efficiency; because in some recent tests which we have been making they were really practice tests, but they brought out this point very nicely—the battery was charged first with uniform current throughout at a rate not such as to produce marked evolution of gas, and its efficiency determined. The same battery was then charged with a tapering current, starting off with a large amount and making the average current for the whole time of charging the same as before. The efficiency was found to be one per cent. of what it was before. Finally, the same battery was charged intermittently with uniform current, breaking and allowing it to stand for half hour intervals, the impression being that there might be a reversible reaction which would take place, so that the battery would have an opportunity to readjust itself between these charging periods, and it was brought to the same condition and again discharged continuously, and all three of these efficiencies came out alike within one or two per cent.

Mr. F. B. Crocker—I would like to ask Doctor Duncan if the question of loss of energy by the evolution of oxygen and hydrogen could not rather easily be determined by collecting the mixed gases. He refers to it as an unknown factor in the loss of energy. It seems to me the number of unknown factors could be reduced by determining the amount of energy the gases represent. The point which the President brought out of a recombination of the oxygen and hydrogen would be eliminated from that also, because the gases collected would represent the actual loss of energy from the evolution, and recombination would be heat added to the heat produced from the battery.

Dr. Duncan—I think I was misunderstood if it was supposed that I said that the loss due to electrolysis of the solution was not a definite quantity. When you electrolyze a solution of sulphuric acid you get a definite amount of oxygen and hydrogen. That has been determined by Gladstone and Tribe But accompanying that is another loss. Gramme found that in electrolysis of dilute acid the efficiency of the process was not much more than 60 per cent. under the most favorable conditions. It is not the 60 per cent. of the loss due to electrolysis that is at all questionable, but where the other 40 per cent. goes to. There is a heating which goes on independently of that, and what that heating is I don't know. Probably Professor Thomson's suggestion will account for some of it. I do not think it would account for all, because most of the calculated amount of gas was collected by Gladstone and Tribe in their experiments.

Mr. Mailloux—There are only two ways in which energy can be abstracted from the circuit proper; just as in a transformer or motor or dynamo; that is to say, either by inductive resistance in the form of counter-electromotive force, or by means of an ohmic resistance. I might point out that the very able and interesting researches of Dr. Duncan will greatly facilitate the mathematical treatment of the storage battery, which thus far has been waiting for just such researches. If we consider the storage battery as a transformer it is very easy to point out its analogy to other forms of transformers, and while generalizations are not correct absolutely to their full limits, yet there are a great many important points of resemblance which will be shown. For instance, the induced currents—the local actions, the peroxide currents which Dr. Duncan has described are very closely analogous to the currents of self-induction, while the losses due to other causes—the loss from heat, for instance, is analogous to the increased resistance due to heat and the consequent loss, and I think that before long somebody will give us analyses of the principles governing the action of a secondary battery with as much clearness and exhaustiveness as we have had in the case of the dynamo or of the transformer.

Mr. Prescott—Dr. Duncan expressed an opinion to the effect that the active material applied to the surface of the plate produces better effects than when applied to a perforated grid. I should like to ask him what he considers the surface of the plate. Is it the surface exposed to the acid or is it the surface of the oxide in contact with the lead? Mr. Wolcott has made a diagram on the board (see above), which shows that the most effective surface is that in contact with the metal itself, and if that is true, why, I should think, the objection to the grid form would fail.

Dr. Duncan—While action takes place all along the grid, yet if the diffusion is not very rapid the action at *b* is taking place in comparatively strong acid and the action at *a*, *a'* (indicating on Mr. Wolcott's figure) is taking place in comparatively weak acid. At the same time the condition of those points is different, therefore the loss will be different. With two plain sheets, one opposite the other, then the density would be exactly uniform, supposing the conductivity of the support were great enough. As far as the efficiency goes the only experiments I have made, as I have stated, were with the deposit of peroxide upon plain lead plates from a solution of litharge caustic. If you take a very concentrated solution of caustic soda and potash and put litharge in and boil it, you get on the lead plate a deposit of spongy lead which will be a half-inch thick for one-quarter of an ounce. Then you can press that until it is about 1-100 of an inch thick. You get about 6-10 of the theoretical capacity of the lead when it is compressed with a pretty fair pressure. It was with such plates that I got a higher efficiency than I did with grid plates, because their action was

perfectly uniform and the thickness is so small that there is hardly a chance of eddy currents.

Mr. Prescott—Therefore it is possible that the same method of preparing the plate if applied to the grid might have given the same result.

Dr. Duncan—The great point here is that every point on the flat plate is in exactly the same condition. The distance from the other plate is exactly the same everywhere. Whereas in case of the grids there are great differences of distance. With the flat plate the distribution of current, and consequently the chemical action, is uniform. In the grid battery the distribution of current varies, and therefore the chemical action varies.

Mr. Prescott—The present practice is to increase the separation of the plates very much more than in the past, and also to make much thicker plates and to make smaller perforations. The result is that the difference in the distance between one plate and any portion of the interior of the perforation of the opposing plate is almost inappreciable. That is the present tendency.

Mr. F. B. Crocker then read a paper on "Electric Motor Regulation." (See p. 253.)

DISCUSSION.

The Chairman [Major Michaelis]—Gentlemen, you have heard Mr. Crocker's paper, which I think I may say, in interest, is in thorough harmonic series with its predecessors. The subject is now open for discussion.

Mr. Wolcott—I would like to ask Mr. Crocker if he has ever observed any difference in sparking between moving one brush and moving both brushes. So far as I have seen, in those machines which only move one brush, the sparking is immaterial. I do not know why it should be so.

Mr. Crocker—I have never observed it and therefore never considered it. It is possible there may be some action there, but I do not see what it could be. When one or more brushes are off the neutral point they spark in proportion to the amount they are removed from the non-sparking point.

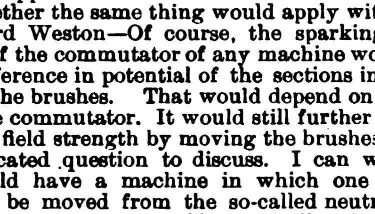
Mr. Wolcott—I can show you a dynamo with one brush on what is supposed to be the correct contact point, and the other one about 100 degrees from it, sparking very little more than it does when set opposite to the first. But this is a dynamo. I do not know whether the same thing would apply with a motor.

Mr. Edward Weston—Of course, the sparking between the two sections of the commutator of any machine would be dependent on the difference in potential of the sections in passing out of contact with the brushes. That would depend on the number of sections in the commutator. It would still further be complicated by changes in field strength by moving the brushes. It would be a very complicated question to discuss. I can well understand how you could have a machine in which one brush or both brushes could be moved from the so-called neutral point to the point of no current and it would practically give no spark, and then again you could have a very heavy spark with some types of machine. With some types of machine it could not be done very well. If you vary the current and so change the difference in the potential of the strip, of course you get a great deal of sparking.

Mr. Wetzler—I would like to ask Mr. Crocker whether he has ever considered the Waterhouse third-brush regulation as applied to motors. If so, I would like to hear what his opinion is in reference to it.

Mr. Crocker—I have considered the matter somewhat, but I never went into it deeply. It never was a very attractive method of regulation to me. The condition in a constant current motor is very similar to that in an arc light dynamo. If a certain regulation is good for an arc light dynamo it is probably on general principles equally good for a constant current motor. But I have not tried third-brush regulation on motors, and am unable to give an opinion as to it practical value.

Mr. Mailloux—There is a peculiar feature of third-brush regulation, in respect to sparking, which was brought to my attention a year or two ago. I am sorry that Mr. Hamilton, the former electrician of the Western Union Telegraph Co., is not here, because he is the man who made the discovery, if it may be called a discovery. (Mr. Mailloux here drew the following figure on the black-board.)



He had occasion to design a machine for telegraphic work, where it was expected to use a third brush for the purpose of getting varying electromotive forces.

He proposed to use a third brush, and to vary that brush to get different voltages for a large number of local circuits for telegraph instruments, and by changing this brush he could so manage that there would be either 10 on each side or else 5 on one side and 15 on the other side. I recollect at the time it was a question as to the possible amount of sparking, particularly as he expected to carry as much current from one side as from the other, and as sometimes one-half would not be working and the other half would be working, it was a question whether there would not be great sparking there, and he told me that he proposed to avoid that entirely. I was greatly interested to know how he proposed to do it, and to my great surprise I found that he had done so entirely by this simple expedient of putting another brush on the opposite side and of connecting them together through a simple galvanometer. Now, we found by practice that as long as these two brushes touch correspondingly so that they were of equal potential, so that there was no current passing through that galvanometer, there was absolutely no sparking—not the slightest trace of it. If we disturbed that connection and if there was no appliance between the two there would be very excessive sparking, but in any case it did not matter where the brushes were located, provided thatboth of them were located at the same point. I cannot account for the phenomenon. It was a very interesting case as showing that there is yet a great deal of mystery to be elucidated about the sparking of dynamo brushes.

Mr. Weston—The case given by Mr. Mailloux is certainly very singular. I am entirely at a loss to understand it. Under the conditions named it would indicate that the difference of potential between the strips had nothing to do with the sparking of the commutator. I shall take the first opportunity to try that experiment.

Mr. Mailloux—I was myself skeptical in speaking to Mr. Hamilton about it. He assured me, however, that he had reasoned it out and that it ought to work, and I only state the fact that he found it to work. There were several persons present and the experiments were very extended. I regret that Mr. Hamilton is not here to give the details and his explanation of the fact. The machine was a large one, probably having a capacity of 10 or 15 h. p. when working at its maximum, and it was tried under large variations of load. The machine was intended to supply local circuits for telegraph work, and, as we know, there might be a large number on or there might be none, and the great aim was to avoid sparking. If I mistake not the machine was put into practical use at Pittsburgh, and may be there yet for all I know. Of course (referring to the figure), I should state that the galvanometer is only used for adjustment, and that the two brushes are connected by a metallic connection of low resistance so that the current supplied to the circuit is derived in equal proportions from both of the two additional brushes. The same thing could be accomplished by connecting a portion of the circuit to each brush.

Dr. Schuyler S. Wheeler—The principal cause of sparking in motors which are regulated, is the fact that the regulator is constantly changing something—either the magnetism of the armature or of the field, in order to effect the regulation; and, as soon as that is done, what is called the line of resultant magnetism is changed, and while the brushes have not been moved, the non-sparking point has been moved away from the brushes, and we no longer have the brushes at the neutral point. Of course, there are two causes of sparking—one is the breaking of the circuit between the brush tip and the commutator, and the other is the short circuiting between the commutator bars, produced by the brush touching two bars at the same time. To avoid this short circuiting, which is by far the most serious cause of sparking, the brushes are always placed upon the commutator at the point where there is no difference of potential between the bars. These points, known as the points of commutation, mark the position of the magnetic poles induced in the armature by the joint actions of the field magnetism and of the winding upon the armature. Its position indicates the combined effects of these two efforts at magnetization, and if the strength of either of them is altered, the position of the resultant polarity in the armature changes. Therefore, whenever we change the intensity of the field or of the armature magnetism we shift the line of resultant magnetism and the brushes are no longer on the right spot. For that reason the method of regulation shown by Mr. Crocker in figure 6, in which the regulation is produced by shunting the current from the whole machine, thereby keeping the relative strength of the armature and the field the same at all times, has the advantage that it will never cause the motor to spark, because, although it alters the power of the machine, it alters the strength of both the armature and the field equally. The method is very objectionable on account of its destroying a large amount of current, namely, all of the current that is taken away from the armature by the shunt, but it has the advantage described, of not causing sparking.

With other forms of regulation, in which the magnetic strength of the field only is varied, it has been necessary to move the brushes, from time to time as the regulator acts, in order to keep them at the proper point; and in some of the forms of motors the brush holders are mechanically connected to the regulator so

as to be moved by it automatically when it changes the field strength.

There is another method of regulation which I have tried experimentally that may be interesting, though it is not at all practical. Figure 12 illustrates the device, which consists of a pair of brushes connected to the terminals of the field winding of an ordinary series motor, and bearing upon a cylindrical piece of copper having long tapering teeth at one end. The spaces between the teeth are insulated and the brushes are so placed that when the cylinder is drawn down by an ordinary centrifugal governor the solid copper is in connection with the brushes and the field magnet coil is short circuited. But when the governor moves the copper cylinder upward on its axis at times when the speed is reduced the toothed portion of the cylinder comes under the brushes, and the tips of the brushes are in contact with the cylin

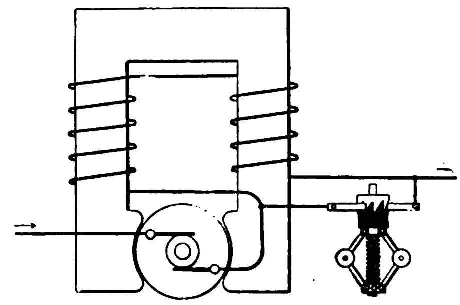


FIG. 12.—(Continuing Mr. Crocker's Series.)

der and thereby in connection with each other only for a part of the time, and are out of connection the rest of the time. The time in contact and the time out of contact depends upon the width of the teeth at the point at which the brushes bear upon them, the position of the cylinder being controlled by the action of the governor. Now, it takes some seconds for the magnetism of the field of an ordinary dynamo or motor to change. Consequently if we make and break this circuit, which short circuits the field very rapidly, we will not lose our magnetism entirely and get it all again; we will simply let down the degree of magnetization, but keep it steady at some point, depending on what proportion of the whole time the circuit is closed and what proportion it is open. That is, if we take a field magnet which requires five seconds to saturate and throw the current on it for one, two three or four seconds, we will attain different degrees of magnetization below the full strength of the machine, and if we arrange the commutator to put the current on and off rapidly and make the aggregate time that the current is on one-fifth of the whole time, we will have a uniform magnetization considerably below the maximum, and without the use of any resistance coils whatever. Of course, the device is not at all practicable, the sparking caused by the large field coils being very serious.

Another method of regulation which I think was not touched upon, although it comes under some of those already described as a sub-class, is that employed by the "C. & C." Motor Co. for a

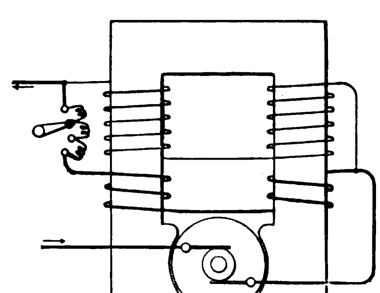


FIG. 13.—(Continuing Mr. Crocker's Series.)

hand regulator. It consists of an armature connected in multiple arc with a field which is divided into a large number of coils. The switch is arranged to throw more or less coils out of circuit by simply short circuiting them. This has the double effect of reducing the strength of the field and of shunting the current away from the armature, and thereby reducing the armature strength, so that in this we have a machine in which the armature is regulated when the machine is operating on a constant current circuit, without the use of any special devices on the armature. By making the first coil of the field of heavy wire and each succeeding coil of a size finer, a machine is made in which the armature and field magnetisms are reduced in something like equal proportions by the action of the switch, and this is done without the use of any outside electrical resistance; but this method has the very serious objection which is sometimes fatal, that the minute the armature speeds up, its counter E. M. F. alters the proportion in which the current divides between the armature and the field circuits. Motors on this plan have been made, however, in considerable numbers, and the reason why this disturbance produced by the counter E. M. F. is not more serious is because the resistance of the field coils may be proportioned to correspond properly with the increases of armature speed, which are apportioned to the several contacts.

The differential winding mentioned in the last part of Mr. Crocker's paper, as one of the methods of regulating constant current motors, consists of two *opposing* field windings with a set of resistances connected in series with one of them for determining which of the opposing windings shall predominate.

There is one other form of regulator, a method invented by Sprague, in which the field coil is permanently connected with the line and the armature terminals are connected by switch to various points on the field, the speed of the machine being regulated by sliding the armature terminals from the centre contacts towards the extremities of the field, which weakens the field and strengthens the armature.

The President—It is my experience that in designing and working the dynamo, nothing is so capable of giving unexpected results now and then, as certain proportioning of the machine.

If none of the other members have anything further to say, I would like to make a few remarks in the general discussion.

Mr. Crocker mentioned that in one of his cases the movement of the brushes of the motor would produce violent sparking. Now, I take exception to that. I say that sparking of that kind is within control, as is the case in dynamos which are built for constant current. Take for instance the modified Gramme form known as the "American" dynamo; in which by a proper adjustment of the over-reach or over-lap of the brushes of the commutator you can displace the brushes enormously and still get no sparking. Apply the same process to a motor and move the brushes, and you will get the same condition. The sparking at the brushes, as I take it, depends on conditions of balance, giving the exact time that is needed for the current in the coil which is going under the brush to lose the current it has been carrying and take up the opposite current. If you give that time exactly in any case you will get no sparking, as in this case your field is constant and your armature current is also constant; there would be nothing to prevent such a balance being preserved at all times. In other words, if we commute our currents in the armature bobbins in a certain density of field, and in shifting the brushes do not disturb the conditions, or if we do disturb those conditions, bring into action other conditions which will adapt the machine to the condition of field or the condition of commutation, then you can control the sparking. In other words, the self-induction is the thing you have to take into account. It takes time in any armature section to reverse the current, and we know that on one side of the brush the current is in one direction and on the other side in another direction. Keep then the coil under the brush for just that time which allows it to pass from five amperes which it may be carrying on one side, to five amperes which it may be carrying on the other side, and you have no sparking in any case. That is one reason why flexibility exists in many forms of dynamo, especially where the armature has a controlling effect in the field, that is, it has some influence on the disposition of the magnetic forces. In cases in which the field is abundantly strong and the armature is a weak magnet, then, of course, the commutation is made in a rather weak field, just before the bobbin reaches the strong field. But if the commutator is placed under the field, that is when the armature bobbin is passed forward under the field, then the conditions are all changed.

I would like to add also another case to Mr. Crocker's cases—one which I worked at for some time and which I found was a fairly satisfactory solution of the problem of constant current motors. I have not very much faith in constant current motors, anyhow. They always require some extraneous mechanism like a governor or something of the kind, which varies the conditions, and that governor is apt to be behind time, especially on the light loads. It may set the motor oscillating. The case is very similar in series work with constant current, to what we find with arc lamps with constant potential. In fact we have instability with arc lamps on constant potential, and we have instability with motors on constant current, for the simple reason that the lowering of speed in the motor drops the counter electromotive force, and we only have a definite certain current to work on; that means a drop in the actual amount of energy available. The time when the motor needs more energy to bring up its speed is the time it loses energy, and that is analogous to the rush of current that will go through an arc lamp put in multiple on a constant potential circuit, because the resistance of the arc falls with the increase of the current. Consequently the more current passes, the more current will pass, and the hot vapor is produced. The case which I referred to as an additional case, is one in which, for constant current purposes, the field is wound in shunt with the armature. (Making a sketch.) We have the field in shunt with the armature, but we vary the field coils in their thickness. We start with thick wire and we go down thinner and still thinner until we end with a rather thin wire. We now make our connections from this at various points, and put a governor on the motor

shaft which will give us a contact to traverse these connections. The armature and field being in shunt the current will always divide between them, and it will be seen that when we have this contact at one point, we have a comparatively high resistance field, or in other words, we have something like a shunt machine; that will be the condition under heavy load. As the load comes off and the speed rises, the field contact passes to another point, cutting out part of the wire. We get then a low resistance field. The current passes through this branch in greater proportion than through the armature branch. The field being low resistance is an economical field, and we get in that way a very fair and economical regulation for series motors. I have built motors on that plan and found they worked very satisfactorily indeed with a proper arrangement for moving the contacts. There is another advantage that I find in such a motor, that the brushes are practically sparkless. That is, they may be set in one position, require no movement at all, even on so few segments as a three-coil armature, and, of course, on a Gramme armature and a multiple segment machine the constancy is even greater; but the brushes are simply set at a certain angle with the line joining the fields, and the governor takes care of this process. The objection to it is that it requires a rather nice construction of the machine. You begin with a coarse wire and go down finer and finer, and to get the grading nicely is a matter of calculation, of course.

Mr. Crocker—I think there is a great difference between motors and dynamos in one respect, and it is a purely practical one; that is, that the dynamo is handled by men who know how to handle machines; they are skilled workmen, and you can afford to have dynamos—they always are—in the hands of skilled workmen; whereas motors are in exactly the opposite position; they are in the hands of the most unskilled people, very likely. Therefore systems of regulation which are perfectly allowable or practical in the case of a dynamo are not so allowable or practical in the case of a motor. In fact, the case just mentioned, of a nice balance in the position of the brushes is an illustration—that is all right in the case of a dynamo where it can be maintained. It probably could not be maintained in the case of a motor.

The President—I would say that we find in working the carbon brushes that you can have quite large variations on account of the resistance of the brush. The spark will be almost insignificant—the resistance of a brush is opposed to any sparking or short-circuiting.

Here a recess of an hour was taken for luncheon.

AFTERNOON SESSION.

When the meeting reassembled, Professor Thomson read a paper on "Magnetism in its Relation to Induced Electromotive Force and Current." (See p. 259.)

DISCUSSION.

The Chairman [Mr. Weston]—Gentlemen, we have had the pleasure of listening to a very able and interesting paper by Professor Thomson, and I am a little sorry that we have not adopted the plan of circulating the papers prior to reading them, so that everyone might be fully prepared to discuss papers of this character. A paper like this requires considerable thought to digest. It has involved much thought in its preparation, and to discuss it intelligently requires more thought than one can bestow upon it in the short time available here. However, the matter is open for discussion and we shall be glad to hear any remarks.

Mr. M. M. Garver—Attention was called to where the phase, with the closed iron, was thrown back 90 degrees farther so that it was exactly opposite to that of the primary. That would furish conditions favorable to coils at right angles to produce a magnetic whirl—a magnetic whirl by using the primary to excite one coil and the current from the secondary to excite another at right angles.

Professor Thomson—No; the angular position in this case would be 180 degrees—not 90. The theoretical position is 90, and 90 added to that gives 180 degrees lag. That does not give you what you desire.

Dr. O A. Moses—There was an interesting hypothesis in Professor Thomson's paper—which was at first blush exceedingly attractive; where he speaks of the action of the expansion and drawing together again of certain rings around a conductor. That is very pretty at the first glance; but there seems to me one insuperable objection, to which I would like to call his attention. Perhaps he may remove it from me instantly. But I cannot conceive of a line of force closed upon itself expanding and producing a flow. It is a closed circuit upon itself. If as in closed circuits there can be no flow in any direction but only upon itself, how is it possible when the electric force emanates from a conductor in the form of a ring, that it can, by a recession upon itself, cut lines of force and produce a flow? There would be a flow in one half of the line and there would be a corresponding negative flow in the other half. So that that hypothesis, in my mind, does not furnish a satisfactory explanation of the flow which Professor Thomson tried to describe. It passed through my mind, and perhaps through the minds of others, that the passage of the current through the conductor might have induced in the ether an adhesion (if we must consider the ether as a substance let us treat it as a substance), and the passage of the ether through the conductor would have dragged atoms of the ether with it and would have produced a vortex whirl; that would account for the closing and the cutting of lines of force from points of high to points of low potential. In that case it would be equivalent of a force at right angles. In the emanation direct from an axial centre, as Professor Thomson suggested, I see nothing to induce a flow. Imagine a vortex ring of smoke ejected from the mouth. The tongue represents exactly the condition of the conductor. The space movement would be the movement of the smoke ring upon itself generated by the motion imparted to the generating force. You have then lines emanating from the conductor going out to points of lower potential, returning upon themselves, but the whole mass simultaneously acting and cutting lines of force from a point of low to one of high potential. That would account for a flow; but a radial emanation I cannot conceive would indicate anything like a flow, because you would be simultaneously drawing upon a centre from all points, producing a flow there which would be neutralized in the other half of the circuit.

Professor Thomson—I do not understand what flow you refer to particularly in this case—the flow of the lines or the flow of the current?

Dr. Moses—The flow of the current engendering as you say this action, which, twined back as it were upon itself, produces the current.

Professor Thomson—I do not think I have advanced any explanation of just exactly how that effect is brought about. I was dealing with the effect itself. There is something which we call the magnetic field, directions in the ether, indicating strains. Those strains appear to me to be relieved by collapsing upon a conductor. Now, it is a fact that when they collapse they give energy to the conductor—how, I don't know. I do not think I advanced any reasoning on that point.

Dr. Moses—It left that impression upon my mind.

Dr. Moses pressed his point at considerable length, illustrating by figures drawn upon the black-board, and was replied to by Professor Thomson. The black-board sketches of Dr. Moses have not been reproduced, and as the further discussion would be somewhat unintelligible without them it is omitted from this report.

Professor Thomson felt compelled to say, at the end, that he scarcely understood the views presented by Dr. Moses.

Mr. Joseph Wetzler—I do not like to prolong this discussion, seeing that there are other papers to be read, but I remember that a few years ago, in a lecture before the New York Electrical Society, Mr. Mailloux, in attempting to explain electro-magnetic induction, employed an analogy somewhat similar to that which Professor Thomson has just brought before us, likening lines of force to springs and the snapping of them on the passage of the conductor. Perhaps Mr. Mailloux may have a few words to say on the subject.

Mr. Mailloux—I thank Mr. Wetzler for recalling the circumstance. My lecture was given in 1883. It is too late for me now to enter at any length into the discussion of Professor Thomson's paper, but perhaps it will be better for me to send in a contribution as a sort of appendix to his paper. I have believed in the theory of the elasticity of lines of force for some years. I employed the term, "resiliency," in my lecture, and I still adhere to it as being somewhat more appropriate, and I have believed for a long time that when the mathematical theory of elasticity shall have been developed sufficiently, we shall have all of the data necessary for working out a perfect theory of magnetism. In other words, I believe that magnetism is nothing more than a manifestation due to the elasticity of the surrounding medium; that it is an elastic disturbance; and I may state in passing that it is here that I differ with the conception advanced by Faraday and Professor Thomson as to the shortening of the lines of force. I think that the idea of shortening is rather vague. I hardly think we can say that lines of force shorten as such. When we introduce a disturbing force as a line we disturb the tension, and the reaction which takes place is merely the result of the forces to produce a readjustment. That is one of the points. Another is the snapping of the lines of force. I shall endeavor to present some experiments showing that this process not only illustrates the fact that lines of force do snap and break, as I did in the lecture of 1883, but I would like at some time to reproduce before the Institute some experiments which would show that the snapping is not simultaneous—if we may adopt the nomenclature of designating the action under the names of lines of force. I like the beautiful expression of Professor Thomson, comparing it rather to an atmosphere.

I will say that Professor Thomson has elaborated the conception far beyond what I have done, and that he has pointed out conclusions which are perfectly logical and which do not appear to be questionable for one moment, and which ought to be of the greatest theoretical and practical value.

Mr. J. P. Wintringham—I would like to ask a single question. In the closed iron ring the magnetism is retained in store, and it is not destroyed until a contrary current is sent through the wire. Suppose there was a current in the contrary direction, and a very

small amount started, would the magnetism of the ring suddenly collapse at some certain point?

Professor Thomson—Hardly, I think. There might be a weakening due to the passage of the current; but until that current becomes of sufficient power to practically overturn all the lines, the sudden collapse could not take place. It is true that that is a good field for experiment, to see just exactly what the relations are in a case of that kind, how much current would be necessary to take out the magnetism of a closed ring. It would depend, I think, on the coercive force present. If the iron were hard a larger current would be needed than in the case of exceedingly soft iron, which approaches perfect freedom of motion as far as these lines go.

Dr. Duncan—I made some experiments on that question. In the first place, with alternating currents we used a transformer and an induction coil of about the same capacity that Professor Thomson spoke of, one with closed and other with opened circuit. We got very much the result that he predicted in theory. That is, the difference in phase in the closed circuit transformer was about 180 degrees; in the other it was about 90. As to the collapsing of the lines of force, it is gradual. After the current begins to reverse, the number of lines of force at first gradually decrease, and then decrease faster, but with soft iron it takes a force about one fourth of that required to saturate the iron.

Mr. George H. Stockbridge—I confess my inability to discuss the paper that has been presented from a scientific point of view. It is suggestive in more ways than one, and must be very fruitful in benefit to all who are dealing with subjects of this kind. It seems to me that in such topics we, as Americans, have been behind the rest of the world. The theoretical principles which govern investigations have been left almost entirely out of sight by Americans generally. I do not mean to say that inventors have not worked intelligently, but I do mean that the workshop of the inventor has been the factory and not the laboratory, and that he has been forced, perhaps by circumstances, to overlook the important field of theoretical work. In other words, he has been: first, an inventor; and secondarily, a scientist; and it seems to me that the Institute should be very glad to receive papers which deal, as the present one does, with the theoretical side of questions.

The Chairman [Mr. Weston]—As I understand Professor Thomson, he does not intend to present any new theory to explain the mechanical processes or movements that take place in the production of a current or a magnetic field. He takes advantage of previously existing theories, and brings before us a mass of facts of great importance in relation to the practical application of the principles involved. I doubt whether any one has had as clear a conception of the action of the transformer as has been presented here to-day. Lines of force are not new, nor is their general study a new subject. Faraday was not the originator of them, as is commonly supposed, but Sturgeon, one of the men who did a vast amount of useful work in the early days of electrical science, but whose name is very seldom seen or referred to. Living at the same time as Faraday lived, he died a few years before Faraday. He was so overshadowed by Faraday's researches that his work has never been fully appreciated. He, I think, was the first man to use the term, "lines of force." I may be mistaken about that. It may be that there was the equivalent of the lines of force in the work of the celebrated Gilbert. His description, and also his drawings, indicate that he had a pretty clear conception of it, but it seems to me that Sturgeon is entitled to more credit in regard to it than is generally given to him. The question as to what is the actual mode of action of these forces is one that we cannot penetrate fully yet. We must wait, probably for some centuries. We are getting clearer notions of the matter. We have got a clear notion that there is such a thing as a magnetic circuit, and such a thing as magnetic resistance. We have got a notion that there is such a thing as an inductive circuit and inductive resistance, and we have got a notion that there is a conductive circuit and conductive resistance. Those terms are employed in a rather free manner, and there is very little doubt that the actions themselves are very closely allied and related to each other. These conceptions have helped us in our practical work a great deal. As to whether we shall not be obliged to abandon finally the lines of force theory, I think is not a matter of very great doubt. There is no question but that it is simply a temporary expedient to enable us to get a fair conception of certain actions that do take place in accordance with certain laws, apparently; just as the atomic theory in chemistry will disappear unquestionably as the mathematical relations of the elements to each other become more clearly understood. They are useful hypotheses, but only hypotheses, and the application of them is not misleading. The subject is too large to discuss very fully. I had made quite a number of notes, but I shall have to give it up, and tender the chair to Professor Thomson.

President Thomson here resumed the chair, and said—I would like to make an announcement, which I believe is in accordance with the ideas of the Institute when there is not sufficient time or opportunity for discussion, that it would be just as well to adopt the plan, often practiced in other societies, of requesting members to write out their comments and hand them in to be published in the proceedings. I think that would enable us to get more matter into a discussion, and oftentimes carefully selected matter.

The following written contribution to the discussion was handed in by Mr. Geo. H. Stockbridge a day or two after the meeting:—

I shall not attempt to discuss Professor Thomson's paper from a scientific point of view, but it seems to me that it is of interest on other grounds, as being, that is to say, a theoretical treatment of an important subject before the American Institute of Electrical Engineers. Such papers have been presented here before, it is true, but they are out of the line of most of our work here in America and are, for that reason, noteworthy. Allusion was made at the meeting last evening to the fact that electrical science has been developed in this country in the factories and not in the laboratories, and that the commercial interests involved have been at war with the scientific.

This has been undoubtedly a striking characteristic of our work, and has led to the charge that our methods are hap-hazard and unscientific; and in view of the silence of even our best known inventors on purely scientific phases of their work, the charge is not to be wondered at. One who is on the ground can understand why the considerations of patent rights and business emulation should keep the mouths of inventors closed, but to an outsider it is not so clear. These business considerations, again, are of far greater importance in a country where the people, less fettered by tradition, eagerly demand every improvement, and so provide rewards for him who is first in the field.

While these facts explain the nature of our inventive record, it is to be feared that the conditions made necessary by the facts —I mean the conditions of silence and secrecy and the hurry to get ahead of somebody else—have tended to make our methods *really* unscientific and hap-hazard. Some of our successful electrical inventors have learned all they ever knew in the factory, and have gone on to a happy-go-lucky success without much idea of what they were doing and what was the force with which they were dealing. It is certain, at least, that the hurried methods induced by competition have produced with some the absolutely unscientific habit of neglecting to make a proper record of experiments. There is no excuse for lighting one's cigar with a 10 dollar bill, and it is equally unpardonable to neglect to preserve for the benefit of others the details of an experiment which did not happen to prove of value to one's self.

This state of things makes its own comment upon a paper like Professor Thomson's. If any of you should take the pains to look back through the files of the Institute's transactions, you cannot fail to note that the majority of the papers dealing with theories have been presented to the Institute by those bearing, like the reader of the present paper, a title indicating the teacher. Professors Anthony and Rowland, Dr. Duncan and Professor Nichols are names which will occur to you at once. In other words, the results show that the laboratory training is, after all, the one which gives us the instinct toward a study of the laws, and a desire to formulate them for the general benefit. It is a matter of congratulation that the instinct and the desire have remained with Professor Thomson, even after a protracted training in the bad scientific school of the factory.

Papers were then read as follows:—"On the Relation Between the Initial and the Average Efficiency of Incandescent Lamps" read by Mr. W. H. Peirce; "The Efficiency of the Arc Lamp," with an introductory note by Professor Nichols, by H. Nakano, of Cornell University (read by Professor Nichols); "The Spiral Coil Voltameter," by Mr. H. J. Ryan read (by Professor Nichols.)

The President—The next paper is on the "Personal Error in Photometry," by Professor Nichols. Professor Cross's paper on "The Measurement of Telephonic Currents," will not be read at this meeting, as the professor is unable to be present.

Owing to the lateness of the hour Professor Nichols asked leave to read his paper by title.

After an announcement that Professor H. A. Rowland would deliver his lecture "On Modern Views with Respect to Electric Currents," in the evening before the Institute and invited guests at the College of the City of New York, the meeting was adjourned.

TELEGRAPHIC STOCK QUOTATIONS SUMMARILY STOPPED BY THE NEW YORK STOCK EXCHANGE.

On the 31st of May the New York Stock Exchange, on the recommendation of its governing committee, discontinued the quotation service of the Gold and Stock Telegraph Co. and the Commercial Telegram Co., and on June 1, returned to the antiquated method of distributing quotations by messenger boys—known in old days as "pushing the pad." The reason assigned for this action by the Stock Exchange is, that it will lead to the suppression of the numerous "bucket shops" which rely upon the ticker service for the quotations that serve as the basis of their gambling business. It is not unreasonable, however, to attribute other motives to the Stock Exchange, and various rumors are afloat as to the real purpose of its action. In some quarters it is thought to be in the interest of the Gold and Stock Telegraph Co., and likely to result in their early return

to the floor of the exchange, and the permanent exclusion of their rival, the Commercial Telegram Co. In other directions it is thought that the Stock Exchange will shortly establish a telegraphic quotation service, in its own hands, to the exclusion of both the companies above named. A third opinion is that the movement is directed against the Consolidated Exchange, which for its quotations of securities has had the benefit of the telegraphic distribution of quotations from the Stock Exchange.

REGULATING TRANSFORMERS.

It is interesting to note that the regulating transformer of Mr. Gisbert Kapp, a description of which in *Industries* was reprinted in the *Electrical Review*, of New York, May 4, was independently invented by Mr. L. B. Stillwell, of Pittsburgh, Pa., and is covered by United States patents Nos. 399,218 and 399,219.

THE EDISON GENERAL ELECTRIC COMPANY.

The consolidation of the several Edison Electric Lighting interests in a new company, the initial steps towards which have been noticed in the press during several months, has been accomplished. The following letter addressed to stockholders in the Edison Electric Light Co., by Mr. J. B. Williams, the president of the new corporation, gives interesting details of the reorganization.

"A corporation called the Edison General Electric Co. has been formed to acquire the stocks of the Edison Electric Light Co. and the three Edison manufacturing companies—to wit: the Edison Machine Works, Edison Lamp Co., and Bergmann & Co.—and for the other purposes set forth in its articles of incorporation. Arrangements are also being made to acquire stock in the Sprague Electric Railway and Motor Co., should it be found desirable to do so.

"The said General company is organized under the laws of the State of New York, with a capital of $12,000,000. Agreements have been signed for the purchase by this new company of the capital stock of the said three manufacturing companies, payable partly in cash and partly in the stock of the new company. The purchase price of the latter is equal to a capital sum on which the net earnings of the three manufacturing companies, as obtained from their books, show a net income of nearly 15 per centum during the year ending November 1, 1888.

"In order to add greater security to the project, it is proposed that, for the present, dividends shall be paid only on a part of the stock received by the shareholders of the Light company and the manufacturing interests in payment for their shares in the old companies; dividends on the remainder to be postponed until such future time as the Board of Trustees of the new company are of opinion that a dividend of at least 8 per centum has been earned.

"The shares of stock in the new company on which the payment of dividends is to be postponed, as above stated, will be deposited by the General company in trust with the Farmers' Loan and Trust Co. of New York city. That company will issue trust certificates to represent the shares of stock thus deposited, and whenever the Board of Trustees of the General company shall declare dividends on the entire capital, the Trust company will, on notice, to all parties in interest, redeem the trust certificates by distributing to the holders thereof the shares of stock of the General company held in trust.

"To provide cash for the immediate needs of the new company and for working capital, a syndicate has been formed to subscribe for stock in the new company, and in addition to the funds received therefrom, stock in the General company to the amount of $2,666,650 will remain unissued for the present, available for use in the future, according to the requirements of that company.

"The shareholders of the Edison Electric Light Co. are now invited to participate in this combination on the following basis:—For each share of $100 of the capital stock of the Edison Electric Light Co. deposited with Messrs. Drexel, Morgan & Co., as hereinafter provided, the depositor is to receive $175 in the stock of the Edison General Electric Co., carrying full rights as to dividends, and $91⅔ in trust certificates, representing stock of like amount in the said General company, on which dividends are deferred. Thus each depositor will receive a total of $266⅔ in stock and stock trust certificates of the General company for each share of Light company stock deposited, making a total of $4,000,000 for the entire $1,500,000 capital stock of that company, all of which is more fully set forth in an agreement, copies of which may be had on application at this office, or at the office of Messrs. Drexel, Morgan & Co.

"In order to avoid, as far as desirable, fractional shares of stock in the General company and fractional amounts in the trust certificates, the same may be equalized by payments in cash in the discretion of Drexel, Morgan & Co., at the par or face value of the said shares or trust certificates, respectively."

It is understood that Mr. Williams represents Mr. Henry Villard, who in due course will take the presidency. Mr. J. H. Herrick, formerly president of the New York Produce Exchange, is expected to assume the vice-presidency.

COLLEGE NOTES.

Harvard.

By an arrangement between the college authorities and the committee in charge of the new Cambridge Industrial School, Harvard men in the electrical and mechanical engineering courses may receive instruction in shop work at the school. In return, the University will establish lectures upon subjects relating to mechanic arts, open to pupils of the school, and to be given by the professors and instructors of physics with the apparatus of the Jefferson laboratory. This will be a great advantage for the school, and will give Harvard men a chance for excellent workshop practice.

A course of lectures on Physical Science has been given at the Jefferson physical laboratory. The lecturers and their subjects were as follows:—

April 11—"Measurement by Means of Light Waves," by Professor Albert A. Michelson.

April 12—"Composite Photography," by Professor Henry P. Bowditch, M. D.

May 3—"Modern Views as to the Nature of the Electric Current," by Professor H. A. Rowland, of Johns Hopkins University.

May 6—"The Acoustic Principles Underlying the Art of Telephony," by Professor Charles R. Cross, of the Institute of Technology.

A prescribed course for freshmen, in the department of physics, has been made up this year of a series of very interesting lectures upon various branches of the subject. The lectures were given by the professors and instructors of physics, and were illustrated by experiments, and by the use of the stereopticon. They were open to all members of the University.

Cornell University—Sibley College.

The new Thompson electrical balance, which was constructed and calibrated in Scotland, has recently been compared with the standard galvanometer in the Magnetic Observatory, and they have been found to agree to within one-tenth of one per cent.

In connection with the thesis work of Messrs. Archbold and Teeple, a very high non-inductive resistance was necessary for use with high potentials. Lead pencil marks on ground-glass were tried, but proved unsatisfactory, the particles of graphite being burnt by the current. Liquid resistance, consisting of small glass tubing filled with a weak solution of copper sulphate, has been found satisfactory. It was necessary, however, to keep the liquid in motion through the tube on account of the formation of bubbles of gas caused by the heating effect of the current. The terminals were placed in jars containing a solution of copper sulphate, and a bent tube connecting them siphoned the liquid from one to the other by alternately raising the level of the jars.

At a meeting of the Electrical Engineering Association, held on May 10, Mr. B. W. Snow, instructor in physics, spoke on the "Recent Researches of Hertz into the Relations Existing Between Electricity and Light." On May 17, Mr. G. D. Shepardson, R. G., spoke on "Thermo-Electricity," considering especially the efficiency of the various methods for the conversion of heat into electricity. On May 24, Mr. L. G. Merritt, '89, gave "Some Facts Concerning Storage Batteries."

During the summer, Messrs. Ryan, Snow and Merritt will make a "Determination of the Electro-Chemical Equivalent of Silver." The large tangent galvanometer will be used in the work. The horizontal intensity and the current will be read simultaneously by means of a method devised by Professor Anthony.

An electrostatic watt-meter and electrometer for alternate current work has been invented by Mr. H. J. Ryan, instructor in physics, and is being built by Mr. Fowler, the mechanician of the department. The instrument is new as to methods, and much is expected from its performance when finished.

The following are the theses presented by the resident graduates and seniors in electrical engineering:—H. Nakano—"Efficiency of Arc Lights;" G. D. Shepardson—"Electricity From Heat;" L. B. Marks—"Life and Efficiency of Arc Light Carbons;" A. Scheible—"A Study of the Magnetic Bridge and Its Applications;" P. B. Woodworth—"Comparison of the Candle-Power of Incandescent Lamps with Direct and Alternating Currents;" W. K. Archbold and G. L. Teeple—"Ball and Point Effect with Alternating Currents;" F. N. Waterman and A. C. Balch—"Third-Brush Regulation for Motors;" L. G. Merritt and H. H. Morehouse—"Tests of Storage Batteries;" J. W. Kirkland and H. E. Baskervill—"Test of the Tesla Motor;" L. H. Parker and F. G. Schlosser—"Test of the Brush Series Motor;" F. Sheble and A. L. Register—"The Curve of Impressed E. M. F. in Alternating Current Machines;" C. R. Van Trump and A. Vickers—"Efficiency Tests of Converters;" "J. W. Upp and E. A. Stege—"Electric Welding;" C. L. Cornell—"Some Relations Between Self-Induction and Static Capacity;" G. H. Ashley—"The Science of Energetics;" B. H. Blood—"Compensated Resistance Standards of Ferro-Manganese Alloys;" E. S. Ferry—"Methods of the Determination of the Effective Area of Armatures."

The June number of *The Crank*, the bright and clever monthly published by the students of Sibley college, will contain abstracts of the above theses.

THE COMMITTEE ON STATE AND MUNICIPAL LEGISLATION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

The resolution creating this committee, was adopted so near the close of the Chicago convention, that little opportunity was afforded to make up its membership or mark out its course of action.

The first problem has been how to secure a committee of able men identified with operating companies, each of whom would represent his state in whatever way might become desirable in giving effect to the plans of the committee.

To secure the best results and to avoid misunderstandings, I printed a list of all names proposed and sent two copies each to the officers and the executive committee of the association, with the request that they would retain one copy for their information and return the other with their suggestions. It became apparent that some persons named were not members of the association, whom it would be very desirable to have on the committee. It was, therefore, thought best to nominate such persons, and invite them to become members of the association at the time they were informed of their nomination as members of the committee for their state. As soon as a majority of the lists were returned, a new list was prepared and sent to the same persons. When a majority of the second lists were returned, a third list was prepared for the information of the persons nominated. It is as follows:—

A. R. FOOTE, Cincinnati, O., Chairman.

1. Alabama—Wm. Gesner, Montgomery.
2. Arkansas—Dean Adams, Little Rock.
3. California—Geo. H. Roe, San Francisco, 227 Stephenson St.
4. Colorado—C. H. Smith, Denver.
5. Connecticut—J. C. English, Bridgeport.
6. Dakota—Judge Stone, Fargo.
7. Delaware—C. Newbold Trump, Wilmington, 50 West Third St.
8. Florida—G. Stuart Smith, St. Augustine.
9. Georgia—Judge H. E. W. Palmer, Atlanta.
10. Illinois—S. L. Nelson, Champaign.
11. Indiana—J. B. Caren, Indianapolis.
12. Iowa—Thomas Officer, Council Bluffs.
13. Kansas—M. Bebee, Hutchinson.
14. Kentucky—A. H. Barret, Louisville.
15. Louisiana—M. J. Hart, New Orleans.
16. Maine—Geo. Westcott, Portland.
17. Maryland—Arthur J. Stewart, Baltimore, 213 East German St.
18. Massachusetts—F. A. Gilbert, Boston, 17 State St.
19. Michigan—J. E. Lockwood, Detroit.
20. Minnesota—S. S. Leonard, Minneapolis.
21. Mississippi—H. P. Hawkins, Greenville.
22. Missouri—J. A. Corby, St. Joseph.
23. Nebraska—Rigan, Omaha.
24. Nevada.
25. New Hampshire—Alonzo Elliott, Manchester.
26. New Jersey—Wm. H. Moore, Plainfield.
27. New York—E. A. Maher, Albany.
28. North Carolina—D. A. Thompkins, Charlotte.
29. Ohio—A. R. Foote, Cincinnati.
30. Oregon—P. F. Morey, Portland.
31. Pennsylvania—A. J. De Camp, Philadelphia, 123 South 11th St.
32. Rhode Island—M. J. Perry, Providence.
33. South Carolina—Geo. B. Edwards, Charleston.
34. Tennessee—Robert L. Morris, Nashville.
35. Texas—David Hall, Galveston.
36. Vermont—J. M. Francisco, Rutland.
37. Virginia—Maurice B. Flynn, Richmond.
38. West Virginia—Jno. B. Garden, Wheeling.
39. Wisconsin—Henry C. Payne, Milwaukee.
40. Washington, D. C.—Geo. Truesdale.
41. Washington Territory—John H. Houghton, Tacoma.

The necessary thing now to be done, is for all who are interested in the association, especially those who made the above nominations, to use the full strength of their influence to secure the acceptance of the appointments and thus complete the organization of the committee. While desiring most earnestly to secure this end, the fact should not be lost sight of, that it is better to have a vacancy, than a name that represents only an address on which time and money must be expended, without securing any co-operative action.

In order that the nominees for the committee may be advised as to the course the committee will be expected to pursue, I prepared the following:—

PLAN OF WORK.

1. An examination will be made of the laws in each state to see in what particular, if any, the electrical industry can be benefited by securing any practicable change in such laws.
2. All bills, affecting in any way the interests of the electrical industry, that were introduced at the last session of the legislature of any state, but which did not become laws, will be examined to ascertain the *tendency of* legislation and to see if it is desirable that they should be passed.
3. Whenever any legislation is desired in any state, or if legislation is proposed that is not desired, copies of the bill proposed will be furnished to the chairman of the committee. He will then furnish the member of the committee for that state such data, arguments and citations as he may be able to provide, to enable said member to place information in the hands of proper persons through whom the desired result may be secured.
4. All work done in one state will be kept in printed form, so that it can be used at once in any other state. The work will thus become accumulative, and of such a thorough character as to be practically irresistible.
5. No legislative measure or economic principle will be advocated in any manner in the name of the committee without the approval of a majority of the whole number of its members, nor will the committee undertake to secure legislation in any state without the approval of the member for that state, and then only when sufficient preparation has been made to render success a reasonable certainty.
6. Each member of the committee will recommend to the chairman an attorney for his state, who will receive and preserve for reference, copies of all documents published or approved by the committee, to the end that if at any time it becomes necessary to employ counsel in that state, or if any special interest requires such service, said attorney will have the desired information and can represent the committee, or such special interest as may wish to employ him, and have at his command much of the data necessary to familiarize himself with the subject.
7. All other considerations being equal, an attorney residing at the capitol of the state will be preferable.
8. The funds of the association are not to be used for any of the expenses of this committee in any manner whatever.

Printed copies of the above were submitted to the officers and executive committee of the association, and with them copies of the letters to be used in inviting the persons nominated to accept the appointments as members of the committee.

In this manner the time since the adjournment of the convention has been occupied in forming the committee and giving shape to an agreed basis for its work. No argument is required to prove that the results which this committee may achieve, will be of great value to all who are interested in any way in the electric industry. It ought to be as readily understood that the principal limitation upon its influence and usefulness, will be fixed by the manner in which those whose interest it is designed to serve, co-operate with and sustain it. None who fail to co-operate with this committee, should ever afterwards be surprised if their isolated efforts prove ineffectual to defeat or change undesirable, or to obtain desirable, state or municipal legislation.

A. R. FOOTE,
Chairman.

MANUFACTURING AND TRADE NOTES.

MESSRS. CHAS. A. SCHIEREN & CO., manufacturers leather belting and lace leather, send us a handsome "folder," containing an illustrated description of their processes and products, and including illustrations of their factory in Brooklyn and of much of the machinery employed by them in the manufacture of belting, lacing, etc. The circular is well got up and will be found interesting reading to purchasers of belting and others who like to get information on manufacturing operations.

THE WESTINGHOUSE ELECTRIC COMPANY has divided the country into districts, appointing in each an agent who is given charge of the selling business throughout his district. This plan of conducting the rapidly increased sales of the alternating current apparatus was begun some months ago, and is now fairly under way.

The company is now represented in their several districts by the following agents: William A. Carey, 620 Atlantic avenue, Boston, Mass.; Henry Hine, 120 Broadway, New York; D. A. Tompkins, Charlotte, N. C.; J. H. Gates, Marshall, Tex.; W. C. Clark, San Francisco, Cal.; Guido Pantaleoni, St. Louis, Mo.; George O. Fairbanks, The Rookery Building, Chicago, Ill.; A. T. Moore, Jr., Denver, Col. H. W. Good, agent for the northwest, has not yet established his office, but will doubtless be located at St. Paul or Minneapolis.

HIGH pressure steam, like high pressure electricity, is attracting increased attention from engineers. The Bigelow company, manufacturers of engines and boilers, New Haven, Conn., are giving special attention to the design and construction of high pressure boilers. They find a demand for this class of boilers and are prepared to make horizontal tubulars up to six feet in diameter for 150 pounds working pressure.

THE MAIN BELTING CO., Philadelphia, have removed to their new factory, 1219-1235 Carpenter street, which they recently built, and where they have a more commodious building and a better location than formerly.

THE STANDARD ELECTRICAL WORKS, of Cincinnati, Ohio, have made some very important changes in their Gravity Annunciator which is meeting with much favor. They report business good, especially in the supply line, and are now completely equipping two large electric railway plants with their entire outfit of wires, insulators, and poles.

THE HILL CLUTCH WORKS, through their eastern manager, Mr. Walter C. Wonham, 18 Cortlandt street, New York, report that they have recently closed contracts for the equipment of the following new electric light stations with power transmission machinery and "Hill" friction clutches: Brush Electric Light Co., of Buffalo, N. Y.; Salem Electric Light Co., Salem, Mass.; Fitchburg Gas Co., Fitchburg, Mass.; City of Bangor Plant, Bangor, Me.; Hudson River State Hospital Plant, Poughkeepsie, N. Y., and have shipped clutch pulleys and couplings to the Western Electric Co., New York; Palmer Manufacturing Co., Brooklyn, N. Y.; E. W. Bliss & Co., Brooklyn; Rilling & Schock, New York; the Butler Hard Rubber Co., Butler N. J.; Jas. Beggs & Co., New York; R. Hoe & Co., New York; Belfast Electric Co., Belfast, Me.; Thomson & Co., New York; L. S. Graves & Son, New York; Adirondack Pulp Co., Gouverneur, N. Y.; Sise, Gibson & Co., Ansonia, Ct.; Standard Light & Power Manufacturing Co., Montpelier, Vt., and the Windsor Plaster Mills, Staten Island, N. Y.

THE THOMSON ELECTRIC WELDING CO., at Lynn, are preparing to increase the capacity of the factory lately erected by them. They are overloaded with orders, and work is being pushed with greatest energy in both their experimental and mechanical departments.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Allegheny, Pa	Observatory Hill Pass. Ry. Co	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co	2	3	Thomson-Houston.
Ansonia, Conn.	Derby Horse Ry. Co	4	1	Thomson-Houston.
Appleton, Wis.	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	20	Daft.
Asheville, N. C	Asheville Street Railway	3.5	4	Sprague.
Atlantic City, N. J	Pennsylvania R. R. Co	6.5	6	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Bangor, Me	Bangor Street Railway Co	5	4	Thomson-Houston.
Binghamton, N. Y	Washington St., Asylum & Park R. R	5	8	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., Brookline Branch	11	23	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	15	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co	4	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	1.5	3	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	3	Daft.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cleveland, Ohio	East Cleveland Railroad Co.	8	16	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenport Central Street Railway Co	3.5	9	Sprague.
Danville, Va	Danville St. C. Co	2	4	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co	9	12	Van Depoele.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	10	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Fort Gratiot, Mich	Gratiot Electric Railway	2	2	Van Depoele.
Harrisburg, Pa	East Harrisburg Pass. Ry. Co	7.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	4	Sprague.
Ithaca, N. Y	Ithaca Street Railway Co	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind	Lafayette Street Ry. Co	3	9	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angelos, Cal	Los Angelos Elec. Ry. Co.	5	4	Daft.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)	1	1	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Highland Line)	2	1	
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3	6	Thomson-Houston
Newark, N. J	Essex Co. Pass. Ry. Co	2.5	4	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
New Orleans, La			1	Daft m'tr and Gibson st'ge battery.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co	9	12	Thomson-Houston.
Pittsburgh, Pa	Pittsburgh, Knoxville & St. Clair St. Railway	2.25	4	Daft.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Reading, Pa	East Reading R. R. Co	2	3	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Richmond, Va	The Richmond Union Pass. Railway Co	13	46	Sprague.
Salem, Mass	Naumkeag Street Ry. Co	2	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
Seattle, Wash. Ter	Seattle Electric Railway and Power Co	5	5	Thomson-Houston
St. Catherine's, Ont	St. Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	6	12	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	10	17	Sprague.
Scranton, Pa	The People's Street Ry	12	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	4	10	Thomson-Houston.
Scranton, Pa	Nayang Cross-Town Ry	1.25	4	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Southington, Conn	Southington & Plantsville Ry. Co	2.2	2	Thomson-Houston.
Syracuse, N. Y	Third Ward Ry. Co	4	8	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co	2.5	6	Sprague.
Topeka, Kan	Topeka Rapid Transit Co	14	12	Thomson-Houston.
Washington, D. C	Eckington & Soldiers' Home Electric Railway Co	2.7	7	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	10	Thomson-Houston.
Wichita, Kan	Riverside & Suburban Ry. Co	6	6	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	3	7	Sprague.
Wilmington, Del	Wilmington City Ry. Co	3	4	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	2	2	Van Depoele.

Total—Roads 72
" Miles 365.10
" Motor Cars.......532

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Atlanta, Ga	Atlanta & Edgewood St. Ry. Co	4.5	4	Thomson-Houston.
Bay City, Mich.	Bay City R. R	5	3	Sprague.
Bay Ridge, Md	Bay Ridge Electric R. R	2	2	Sprague.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets			Bentley-Knight.
Buffalo, N. Y	Buffalo, St. Ry. Co	2.5	4	Sprague.
Cincinnati, O	Cinc. and Inclined Plane Ry	6	20	Sprague.
Cincinnati, O	Cincinnati St. Ry. Co	2.7	8	Thomson-Houston.
Cincinnati, O	Colerain Ave. Ry. Co.	2.75	8	Thomson-Houston.
Cleveland, O	Collamer Line, East Cleveland, O	3	8	Sprague.
Decatur, Ill	Citizen's Electric St. Ry	5	4	Thomson-Houston.
Dubuque, Ia	Key City Electric Ry	2	4	Sprague.
Eau Claire, Wis	Eau Claire St. Ry	5	6	Sprague.
Erie, Pa	Erie City Pass. R. R. Co	12	20	Sprague.
Kansas City, Mo.	Vine St. Ry		6	Thomson-Houston.
Kansas City, Mo	Metropolitan St. Ry. Co	2.25	8	
Laredo, Texas	Laredo City R. R	4	4	Sprague.
Lynn, Mass	Lynn & Boston R. R. Co. (Nahant Line)	.8	1	Thomson-Houston.
Long Island City, N. Y.	Long Island City & Newton Electric R. R.	3	2	Sprague.
Louisville, Ky	Central Pass. R. R. Co		10	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Marlboro, Mass	Marlboro St. Ry. Co	3	2	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Newburyport, Mass	Newburyport & Amesbury Horse Ry. Co	6	2	Thomson-Houston.
Newton, Mass	Newton Circuit Line	8	10	Thomson-Houston.
New York, N. Y	North & East River Ry. Co.	3	20	Bentley-Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	5	20	Thomson-Houston.
Omaha, Neb	Omaha Horse R. R	10	20	Sprague.
Ontario, Cal	Ontario & San Antonio Heights Ry. Co	8	4	Daft.
Ottawa, Ill		6	8	Thomson-Houston.
Pittsburg, Pa	Federal Street & Pleasant Valley R. R	8½	25	Sprague.
Pittsburgh, Pa	Pittsburgh Suburban Rapid Transit Co		3	Daft.
Plattsmouth, Neb	Plattsmouth Electric R. R	2	2	Sprague.
Plymouth, Mass	Plymouth & Kingston Ry. Co	4	3	Thomson-Houston.
Port Chester, N. Y	P. C. & Rye Beach Street Railway Co	3	5	Daft.
Portland, Oregon	Metropolitan R. R	3	4	Sprague.
Portland, Ore	Willamette Bridge Co	1.5	5	Sprague.
Quincy, Mass	Quincy St. Ry	5	4	Thomson-Houston.
Redbank, N. J	Redbank & Seabright Ry	5	3	Thomson-Houston.
Revere, Mass. (Ex.)	Revere St. Ry. Co	1	1	Thomson-Houston.
Richmond, Ind.	Richmond St. Ry. Co	4	6	Thomson-Houston.
Richmond, Va	Richmond City Ry. Co	7.5	50	Sprague.
Rochester, N. Y	Rochester Electric Ry. Co	7	8	Thomson-Houston.
Salt Lake, Utah	Salt Lake City R. R. Co	6.5	10	Sprague.
St. Joseph, Mo	People's R. R. Co	10	20	Sprague.
St. Joseph, Mo	Wyatt Park Ry. Co. (Northern Division)	4.5	9	Sprague.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Electric Ry	6.75	6	Sprague.
Scranton, Pa	Hillside Coal Co	1	1	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Spokane Falls, W. T.	Ross Park St. Ry. Co	7.50	6	Thomson-Houston.
Springfield, Mo				Fisher.
St. Louis, Mo.	Lindell Ave. R. R	5½	10	Sprague.
Stillwater, Minn	Stillwater Electric St. Ry	5	6	Sprague.
Sterling, Ill	Union Electric R. R	6	7	Sprague.
Tacoma, Wash. Ter	Pacific Ave. St. R. R	6	6	Sprague.
Tacoma, Wash. Ter	Tacoma Ave. St. Ry. Co	2	4	Thomson-Houston.
Toledo, O	Toledo Electric Ry. Co	2	4	Sprague.
Troy, N. Y	Troy & Lansingburg Street R. R	5	6	Sprague.
Wichita, Kan	Wichita & Suburban Ry. Co.	7.5	7	Sprague.
Wilkesbarre, Pa	Wilkesbarre & West Side R. R	4	3	Sprague.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.

Total—Roads 62

Notes.

THE THOMSON-HOUSTON COMPANY has devised a mill and factory electric tramway to meet the need of better facilities for the handling of supplies and products in large manufacturing establishments. The large number of mills supplied with electric lighting systems can easily add electric tramways, and it is safe to predict that before long the electric tramway will come to be considered a necessary feature in mill equipment. The Thomson-Houston Electric Co. has already equipped several tramways, and has contracted for others which will soon be put in operation.

The tramway car at the company's works in Lynn is used for carrying heavy machines and unfinished work to different parts of the factory, and its use permits the handling of apparatus with much greater ease, in less time, and with less labor than could possibly be accomplished by any other method. The car is equipped with two 3-h. p. motors, and easily carries up a grade of 13 per cent. a load of five tons, while from 8 to 10 tons can be carried on a level. The motors receive their current through an overhead wire from one of the generators in the factory.

THE DAFT electric railway at Cincinnati, which was opened for business late in April, and has been in successful operation since, is equipped with the double trolley system of underneath contact, and is the only road now running upon that plan.

THE SPRAGUE ELECTRIC RAILWAY at Atlantic City, N. J., was put into operation about May 1, with entire success. The cars ran over the entire distance of the road at a speed exceeding 15 miles an hour, each towing another car behind it. Officials of the road were present, and were much gratified by the performance of the cars, their ease at starting, and in rounding the curves. The equipment of this road includes the new 15 h. p. motors of the Sprague company, and all the latest devices and improvements in use by the Sprague company. The system of roads at Atlantic City, which is now being completely equipped with electricity, is controlled by the Pennsylvania Railroad Co. This road will carry large numbers of passengers during the summer season.

THE JULIEN ELECTRIC TRACTION CO. announces that it has closed a contract with the Union Passenger railway, of Providence, for the introduction of its storage battery system on their lines, and that cars are now being constructed for them. The 30 cars being built by Mr. Stephenson are being rapidly pushed forward, and deliveries will begin at an early day in June.

EXHIBITION AND TEST OF THE WIDDIFIELD AND BOWMAN BRAKE.

A very interesting and successful series of tests were made with the Widdifield and Bowman electric and automatic brake on the Lehigh Valley railroad, on Tuesday, May 21. A special car was attached to the regular train which left Jersey City at 8.15 A. M., arriving at Mauch Chunk for dinner, after which the party boarded a freight train in waiting, consisting of 14 cars equipped with the brake. Several "emergency" stops were made while the train was proceeding at speeds varying from 25 to 37 miles an hour, within 17 to 27 seconds. Tests were also given of "long service stop" "slow up to five miles an hour—release and go ahead," "service stop," "fly cars into siding," "break away." The operation of the brake is instantaneous both when applied and when released, the action being dependent upon the magnetization of an induction coil, which is energized by a current from 10 storage batteries in the engine. It will be seen, therefore, that the brakes can be set or released by the movement of a switch. An ingenious contrivance is used whereby the power required to apply the brakes is taken from the axles, the electric current being used merely to set the apparatus in action, and to secure quick release. The inventors of this brake have been experimenting for several years, but it has only been recently that they have secured a standard which they are confident will produce the desired results under all conditions. Among those present, were: J. W. Kendrick, chief engineer Northern Pacific railroad, St. Paul, Minn.; Captain William H. Thompson, Equitable Life Assurance Society, New York; W. C. Baird, Brooklyn; Thos. R. Fuller, Toronto, Can.; Edward P. Thompson, patent attorney; Messrs. Widdifield and Bowman, the inventors; Paul M. Richards, publisher *New York Observer*; C. B. Fairchild, *Journal of Railway Appliances*, New York; T. W. Sprague, *Electrical Review*, and the representative of the ELECTRICAL ENGINEER.

THE PARIS EXHIBITION.

The International Exhibition, commemorative of the revolution of a hundred years ago, was successfully inaugurated May 1, with imposing ceremonies. The electrical part of the display will, apparently, be very extensive and complete, the American exhibits taking a prominent place. The elaborate displays of Mr. Edison and of Professor Elihu Thomson alone furnishing an exhibit of American inventiveness and progress sufficient to occupy the attention of visitors interested in the arts of electricity for a good many days, while the apparatus shown by the many prominent European electricians and manufacturers will make the display a well nigh complete exposition of the present state of electrical industries.

.... THE consumption of gas is so great that gas companies' shares have constituted the best investment. If gas were supplied as a cheap heating power, for which electricity is not adapted, gas companies would make still larger fortunes, and would free towns from the funereal cloud which not unfrequently lowers over them —*Professor Ayrton.*

LEGAL NOTES.

THE SAWYER-MAN PATENT.
THE WESTINGHOUSE-EDISON SUIT.

The oral arguments in the suit of the Consolidated Electric Light Company against the McKeesport Light Company, commenced in the United States Circuit Court at Pittsburgh on May 21, before Justice Bradley of the United States Supreme Court, and Justice McKennan of the Circuit Court, and continued for three days. This is really a contest between the Westinghouse Electric Company of Pittsburgh and the Edison Electric Light Company of New York, involving the essential feature, or at least one essential feature, of the modern incandescent lamp. The suit is brought on the patent of Sawyer and Man, No. 317,676, granted May 12, 1885, on an application filed January 9, 1880. This application was put in interference with a similar application of Edison, filed a month before, and after repeated hearings, rehearings and appeals in the Patent Office, was finally decided in favor of Sawyer and Man and their patent issued. Testimony has been taken amounting to some 3,000 printed pages, within an unprecedentedly short time, as both sides were apparently anxious to obtain an early adjudication of the question at issue.

ARGUMENT OF HON. JOHN DALZELL.

The case for the complainant was opened on Tuesday morning by Hon. John Dalzell. Mr. Dalzell briefly reviewed the prior state of the art with reference to the claim of complainant's patent, which covers "an incandescing conductor for an electric lamp of carbonized fibrous or textile material and of an arch or horseshoe shape," and the same in combination with a glass enclosing chamber free from carbon consuming gas. He maintained that prior to the Sawyer and Man invention no commercially successful lamp had been devised; that every element of the modern commercial lamp was known except the conductor of carbonized fibrous or textile material; that no prior lamp contained an incandescent conductor of carbonized fibrous material enclosed in a sealed chamber; that no lamp having those elements had contained an incandescent conductor in the shape of an arch, and finally, that every successful modern incandescent lamp contains a conductor of carbonized fibrous material of an arch or loop form enclosed in a globe. It was necessary to sustain these propositions in order to be successful is the case. He proceeded to point out the advantages of the fibrous carbon, and explained that by forming it into an arch the danger of breakage by expansion and contraction was avoided; how this form enabled a greater length of carbon to be placed within a globe, and how the distribution of light was rendered more uniform thereby. Taking up next the question of infringement, he exhibited defendant's lamp to the Court, and showed that its conductor was of carbonized bamboo, a fibrous vegetable material, and that it was in an arch or horseshoe shape. The infringement was established by the testimony of the witnesses of both complainant and defendant. He then detailed the history of the invention of Sawyer and Man, showing by citations from the testimony that paper carbons were made by them as early as March, 1878, and that lamps in operation with paper carbons were publicly exhibited in October, 1878, in New York. He referred to certain communications which passed between Mr. Man and Mr. Lowrey, the attorney of the Edison company, in October, 1878, with reference to Sawyer and Man's inventions, and to a visit by Mr. Lowrey and a number of other gentlemen interested in the Edison inventions to the Sawyer and Man factory in the latter part of March, 1879. Mr. Dalzell next spoke of the publication of a description of Edison's successful lamp in the *New York Herald* of December 21, 1879, and said that the application of Sawyer and Man for a patent was filed on the 9th of January following. He then gave at some length a history of the interference proceedings, terminating in the decision by the Examiner on January 20, 1882, deciding the question of priority of invention in favor of Sawyer and Man. The case was reopened on a motion in behalf of Edison, further testimony was taken, a rehearing was had, and on June 2, 1883, the Examiner of Interferences again decided in favor of Sawyer and Man, holding that they completed the invention the year before Edison did, and never abandoned it. Edison appealed the case to the Board of Examiners-in-Chief, who decided in his favor, on the ground that Sawyer and Man's conductor was not properly a paper conductor because it had been treated by the hydro-carbon process and its surface or lighting giving portion covered with deposited carbon. The case was finally appealed to the Commissioner of Patents, who in his decision said: "I think it is fully and clearly shown that Sawyer and Man were the first inventors of the incandescent conductor for an electric lamp formed of carbonized paper." Edison then appealed to the Secretary of the Interior who dismissed the appeal, holding that he had no jurisdiction. He then moved for a rehearing before the Commissioner, which was denied on the ground that the question had been treated by both parties to the interference and by the Patent Office, as an examination as to who was the prior inventor of a *fibrous carbon*, which in fact had been admitted by Mr. Edison himself in another proceeding. Sawyer and Man then amended their claims to include fibrous carbon in general as well as the specific form of paper carbon. After the interference proceedings were decided and the Sawyer-Man patent issued, Edison demanded a second interference upon the fibrous carbon claims of the Sawyer and Man patent, which he had amended his own specification to include. This was refused on the 27th of June on the ground that the question had been decided in the original interference. Mr. Dalzell said that the patentee of the carbonized paper conductor was really the patentee of all the genus of which that was a sample and species.

Mr. Dalzell argued at considerable length that as matter of

law the decision of the Patent Office upon the question of priority was *res adjudicata* in the Court as between these parties. He then detailed the immense growth of the business of lamp manufacture since 1880, and said that upon the issue of complainant's patent, all other companies except the Edison company, became licensees of the Sawyer-Man company. Shortly after the issuing of the patent a suit was commenced by this complainant against the Edison company in the Southern District of New York, but owing to various delays, interposed by the defendant, has never reached a hearing. In conclusion, he said that the only real question was: Which of these parties first invented this thing, which all the world knew, and which Mr. Edison himself has declared, to be both a novel and useful invention?

ARGUMENT OF GROSVENOR P. LOWREY.

Grosvenor P. Lowrey, of New York, opened the case for the defendant. He said that the defendant would maintain that the production of the electric light by the incandescence of a conductor; the use of carbon in incandescent lamps; the use of fibrous carbon; the use of the arch form both in metal and in carbon, and the hermetically sealed lamp chamber were all old, and that in 1878, in view of the state of the art, there was no invention in combining the arch shaped conductor of fibrous or textile material with a hermetically sealed lamp chamber. In 1879 Edison developed a perfect commercial lamp, consisting of a filamentary incandescent conductor of paper inclosed in a vacuum chamber entirely of glass. The complainant's lamp is impracticable, never went into use, and shows not one essential element for a successful lamp. Defendant would contend that the essential elements of the successful lamp, used by both parties, are an incandescent conductor of filamentary form, of high resistance and small radiating surface, in a vacuum, and a lamp chamber entirely of glass in a single piece; that there is no connection in art or in law between the paper or wood carbon of Sawyer and Man and the fine bamboo filament of the modern lamp; that the line of work pursued by Edison and that pursued by Sawyer and Man were diametrically opposite in principle and method, as to size and resistance of conductor, and that the fact that fibre may have been used by each was a mere matter of accident without legal significance; and finally, that the testimony adduced by complainants in respect to the work of Sawyer and Man is untrustworthy and in many respects demonstrably false, and their patent was by unlawful amendment prepared with the design not to protect but to capture an invention. Before addressing himself to the case, Mr. Lowrey indignantly repelled the odium and discredit which he said had been sought to be put upon him by complainant's counsel who had just spoken, in connection with his visit to the Sawyer-Man factory in 1879. He said that if the statement of counsel had not been intended to leave the impression upon the mind of the Court that the invention of Mr. Edison resulted from that visit, it was meaningless, and hence it was imperative that he should refute the gross imputation which had been put upon him. Mr. Lowrey then quoted from the testimony of Mr. Man, one of the complainant's witnesses, that the fibrous arched carbon was not shown on the occasion referred to, and from the testimony of a number of gentlemen who accompanied the speaker at the time, that none of them saw or heard of the fibrous arched carbon. Mr. Lowrey continuing said, that this allegation was a sample brick of the whole structure. There was not an honest thread in the case from top to bottom. There had not been a fact alluded to that day upon which a false construction had not been placed; the whole thing is like a glass a little out of adjustment so that everything seems false. He proposed without invective or undue violence of language to deal with this seriously as a case which he entirely distrusted. He did not believe it was an honest case in any particular. He hoped to convince the Court that this was a case to distrust, from the very beginning; there was not one of their facts that had not a trick in it.

Mr. Lowrey then proceeded to discuss the merits of the case. Holding up an Edison incandescent lamp, he said: the defendants were contending for the right to make that lamp. There were two parties engaged in making and using that lamp, the complainant in this case, and the Edison company. Their Honors would perceive that they did not differ in any essential respect. They were both constituted by a fine fibre of carbon inclosed in a lamp chamber, from which the air has been exhausted to the millionth of an atmosphere, a thing not known until 1878 or 1879, when it became possible by the adoption of the Sprengel pump. In these lamps the material thing is the fineness of the filament, without which electric lighting would be impossible. It was the discovery of *that*, without reference to the material being fibrous or otherwise, which made the electric light possible. That lamp, it would not be denied, was first made and given to the world by Thomas A. Edison, who, in December, 1879, made one hundred such lamps. Twenty-five thousand people saw those lamps burned within a few days of the 25th of December. Now complainant's contention is for the right to use that; the claim being made upon a statement that such a lamp was made in 1878, and that the illuminant was of fibrous material and in an arch form, which defendant did not believe was true, and should ask the Court to disbelieve also, in any serious sense. The right to make this lamp, by the man who gave it to the world and who first patented its principle, is disputed. Mr. Lowrey then read from the specification of Sawyer and Man as originally filed, saying that it did not contain the invention now claimed, and then referred to Edison's patent of January 27, 1880, for incandescent lamps of high resistance, which he contended was the basis and foundation of the electric lighting industry of modern times. The material from which the carbon is made amounts to almost nothing, the thing of real importance in the art, is lamps which shall have high resistance to allow the practical subdivision of the electric light. There their Honors would see the patents upon which the contending devices stand; one, a success, the principle of electric lighting which has made that art a success, the other, a device, the principle of which was absolutely at war with success.

At this point the Court adjourned for the day. The following morning Mr. Lowrey resumed for the defense. The industrial art of electric lighting, he said, has had but a short life. Arc lighting was practiced in a few places, but incandescent lighting has vastly surpassed it, and since 1879 this has all been done by the little lamp, the glow lamp, which shed its glow first at Menlo Park on the 20th or 21st of December, 1879. It has never ceased to glow, it never did to the common knowledge glow before that. For a month or so, paper cut and carbonized served for the incandescing conductor, but within a month Mr. Edison, by a series of experiments so original, so extensive, so admirable as scarcely to be rivaled, reached the conclusion that the inner bark of the bamboo plant was the thing to be used. He adopted bamboo, and bamboo has ever since remained the incandescing material of almost all glow lamps in this country, and perhaps in the world. Mr. Lowrey then exhibited to the Court the lamps now made by the complainant and defendant, and pointed out that they were substantially the same. The Consolidated company had brought a suit upon their patent justifying a certain construction, and then had adopted another, Mr. Edison's construction. There is the thing, and there is the man (pointing to Mr. Edison who sat beside him) who gave it, and here is the thing, and here is the man who has taken it from him. It was not until the experiments of physicists, who had obtained a more perfect vacuum, came to the knowledge of Mr. Edison, that he said, "here it comes, here is the condition; now we will dismiss platinum and go back to carbon, which we always knew was the thing, but which we could not burn in the open air." The difference between this lamp and that lamp, which makes them totally different, so that one may said to be aimed towards the south pole and the other towards the north pole, so that they can never meet, is the difference of *resistance*; in that lies the crucial question and difficulty, and the master key that unlocked that difficulty was that little fine-spun filament, which may be of carbon or of anything else having the highest attainable resistance and a very small radiating surface. It is said in respect to the telephone that even the Morse instrument can now be made to talk. We say in reference to complainant's lamp that almost anything will burn for a while. How many times they tried to do it, how many times they failed we have no means of knowing. He would say with reference to their experiment that it is to be entirely distrusted and put aside. Mr. Lowrey then explained at length the practical effects of the difference in resistance between the lamp of Edison and the lamp of Sawyer and Man, showing that one was adapted to multiple arc distribution, and the other not, and said that the cost of copper conductors in the plant now building in Brooklyn, might be $195,000 with Edison lamps, whereas with Sawyer-Man lamps of low resistance it would be $30,000,000. That was the condition in which the art was found by Edison in 1877. He brought to it not only great acumen in science and in art, great resources, unrivaled industry, and unique qualities of every sort, but the great brain and comprehension of a magican, philosopher and a business man. He determined that it was commercially necessary that the customer should be put into the same relation to the supply and to their co-consumers as the consumers of water and gas. He saw that not the series but the multiple-arc system was the thing. Edison was correct in saying that the general scientific opinion was that it could not be done.

Mr. Pope, one of complainant's experts, thought Mr. Edison had mistaken the opinion of a class of semi-scientists who make up in pretension what they lack in knowledge, for that of the real scientific world, and in support of his views had produced extracts from testimony taken before a parliamentary committee in 1879 as to whether it was probable the electric light could be subdivided, and whether Edison had done it. He would presently call their Honors' attention to what he regarded as not a creditable way of diverting attention from the true meaning of what was said by these witnesses. He then read at length from the testimony of Conrad W. Cooke, W. H. Preece, Dr. C. W. Siemens, Professor Tyndall, and Sir Wm. Thomson, before the committee, contending that the extracts supported Mr. Edison's opinion. Now he would call attention to the way in which complainant sought to break the force of this fact. The experts said Mr. Edison knew nothing about it, but when it turned out afterwards he could do it, they said "we meant it could not be done in that way." He

would point out that they knew nothing about it; that this explanation was an afterthought, of which this case was full. It was a case supported upon misconceptions of law, and of science, and upon a well edited series of afterthoughts. Mr. Lowrey then read several severely adverse criticisms from English technical journals written after the successful demonstration at Menlo Park, and after a description of the system had been published in *Scribners' Monthly*. To break the force of this, a most excellent electrician, and a good man, Mr. Pope, was driven to a desperate strait. In order that their Honors should see the true inwardness of the explanation and the necessity he was under to make it, he should call attention to the question put to Mr. Pope. He was shown a letter in an English journal severely criticising Edison's scheme, and acknowledged that it contained the substance, though not the words of a private letter written by himself. On re-direct he said the system referred to in the letter, was that of platinum lamps with thermal regulators, in multiple arc distribution, which was afterwards found impracticable and was abandoned. The letter of Pope in which he had said: "Don't take any stock in this thing, the system is of no account," was dated February 1st, 1879. Their Honors would be interested to learn now, that the thermo-regulator lamp was first known to the world April 22, 1879. This again is one of those instances of sight behind, so much better than sight before. Mr. Pope is now able to remember that on February 1st, 1879, he denounced a particular kind of lamp, and that lamp did not appear and was not known to the world until April 22, 1879. Their Honors would see that there were very serious and strong exigencies in this case; denials are called for that must be very wearing to the conscience. He trusted he had made it clear that the intimation which produced the excitement in gas shares referred not to any system, for Edison had not then announced any system, he had simply felt it with his genius. When this man of international reputation had said he believed he could do it, up rose other scientific men and said "it cannot be done, and we will prove it by figures," and down went the gas stock, proving by figures that the public believed that what Edison had said he would do, he probably would do. Mr. Edison in 1879 came to the subject of electric lighting bringing a greater knowledge of carbon, perhaps, than any other man in the world. He had been engaged on the carbon telephone; he knew exactly what could be done with carbon. In 1879 when the Gramme machine was given to the world, he took up again electric lighting. He carbonized paper and wood; tested their resistance. In 1877 strips of carbonized paper were placed in vacuo and brought to incandescence, but the vacuum was poor and the carbon oxidized almost as rapidly as it did in the air. There the experiments stopped, and Mr. Edison went upon other subjects, yet with this in his mind: "carbon is good, paper is good to make carbon of, any kind of carbon is good." He probably did not think whether it was fibrous or non fibrous. He said: "How shall we get a place where we can protect it?" He went on. He tried platinum. He was master of the situation; whether carbon or platinum, it is utterly useless unless we can make a commercial system. "How can it be done?" It did not take that man long to see that it was by increasing the resistance. There was formulated presently, what he should call the law of Mr. Edison, that commercial incandescent lighting depends upon incandescent conductors, filamentary in form, high in resistance, and durable for a given time. That was the mixed commercial and scientific law, and he worked always after that, not to find carbon, not to find metal, but to find whatever would yield to the conditions and would give this high resistance, until finally, by a series of wonderful experiments he was led to adopt the fine hair-like fibre of bamboo, and is then met by the cry: "Don't touch vegetable carbon, because last week we used some paper, and some cabbage, and although we have not got much of a light, we claim all that." As there is no other world accessible to us where we can get carbon, Mr. Edison would be in fine plight, and so would the state of the art; there would be no electric light to-day if he had been shut out from that.

Mr. Edison experimentally determined that under certain conditions carbon would not do. Those conditions Mr. Man did not supply; they were finally secured by making the lamp chamber wholly of glass, fused together and around the platinum conducting wires. They say they have a lamp chamber entirely of glass because two pieces are put together and held there. We say, "A lamp of one entire piece of glass" needing no clamping, no sealing by means of unctuous material. This (holding up the Sawyer-Man lamp) is a kind of lamp chimney for which you need an affidavit; it cannot be seen to burn except by experts.

Mr. Edison proceeded to experiment with platinum, which is not only expensive, but is 250 times less economical than carbon, because its resistance is 250 times less. While experimenting upon platinum in 1878, he again tried carbon. He gave his laboratory up to this subject. He says "the subdivision of the electric light into small units comparable with that of the ordinary gas jet, was what I thought was required. The general scientific opinion was that this could not be done. The first thing necessary to be done was to adopt a fundamentally correct system of distributing the current and then to devise what could be worked practically on such a system. Mr. Lowrey quoted further from the testimony of Edison showing that he first made a commercial lamp in October 1879, the lamp chamber being exhausted to one millionth of an atmosphere. When he had made one lamp, he naturally inquired "how many different kinds of this thing can we use," and he proceeded to experiment; he carbonized everything. This thing was reached by empirical experiment. The testimony of Dr. Wilson, the botanist, shows that the last thing which would be suggested was bamboo; it was found by experimenting. Mr. Edison did not stop by sending to a place where they sold fish poles, to get pieces to carbonize; he despatched a man to China and Japan, to get samples of every kind. Here he would pause to indicate another of those instances which indicate trustworthiness of the work in Edison's laboratory and untrustworthiness of Sawyer and Man's. Their testimony does not show an actual life test applied to any one lamp. When an incandescent conductor broke, they took the lamp structure apart and put in another, and then it was a new lamp and was counted twice, so there was absolutely no life test. When Mr. Edison talks of life tests he sets up never less than 100. He watches them, keeping an absolute history of each one. He says :—"I have kept up my search for different qualities of bamboo and all other material; since 1880, I have sent one man up the Amazon, another to Uraguay and Paraguay, and up the river La Plata; two more were afterwards sent up the Amazon near its head waters; two others to the West India Islands, and thence to British Guiana, to the United States of Colombia, and up the Magdalena river; another to Mexico. One has just returned from a year's search in Ceylon and India; I have now a man in the Cauca Valley in Colombia. I have received and carbonized, made into lamps, and tested not less than 6,000 species of vegetable growths." This at an expense of hundreds of thousands of dollars. The results are shown by the fact that in 1883, the Consolidated Lamp Co., which had a perfect right to make *that* lamp, determined to make it no longer. *This* is the lamp they determined to make. It is the result of Edison's large expenditure of money and of the travels of his agents in foreign lands.

Assuming that in 1878, they discovered that the use of paper carbon in the bent form was new, that they had made and announced to the world that great discovery saying "take notice, vegetable fibre is ours, and we estop you," it is nevertheless an undoubted fact, that in respect to final success in this art, Edison alone has made any effort entitled to recognition in the world of scientific progress.

He would now endeavor to give their Honors some of the reasons why complainants adopted this form of our invention. Reading from the examination of Mr. Edison :—"Q. How large a proportion of these vegetable growths did you find at all suitable for your purpose? A. Only about three species of bamboo, one species of a peculiar cane that grows on the Amazon, and one or two species of fibres from the agave family."

He would show from the testimony of Mr. Man, that the invention was necessary; that it was perfected through legitimate channels without effort. He then read at length from the testimony of Mr. Man, as to his experiments, and said that one would be justified in expecting a performance more in keeping with the results, but in vain; the patent says nothing whatever excepting "We have used carbonized paper and wood carbon." They said nothing, because they had nothing to say. They had absolutely done nothing which could be considered an invention or a discovery in the art. Mr. Edison says the fibrous structure is a disadvantage; what is wanted is a cellular structure, even and homogeneous, the same in all directions. Out of the 6,000 vegetable carbons which he has tried none but the three or four mentioned were sufficiently good for his purpose—the production of a good commercial lamp easily and cheaply manufactured.

He would refer again to the statement of Mr. Pope as to the value of a certain claim. The difference between the one inventor and the other was emphasized in nothing so much as the fact, that one man sent a representative to the further limit of South America, where it is possible for one man to exist although two cannot; and the other hired a patent attorney who drew certain claims and had them patented in his name. He would now devote some attention to the patent. It would be clear to their Honors that that sort of man, having done that sort of work, and produced that sort of lamp, finding himself in December, 1879, face to face with a description in a newspaper, of a patent of something he might have dreamed of, but never sought; this man would be very likely to perceive the superiority of Edison's success, and he got a patent upon the principle of bending a carbon filament of fibrous textile material, enclosed in an hermetically sealed globe, and capable of high resistance as an incandescent conductor.

On December 21, 1879, was published in the *New York Herald*, an article in which the world was notified that this lamp had been produced by Edison; that the material of the conductor was carbon, and the form was for the first time termed a "horseshoe." It came to be at once universally known as the "horseshoe lamp." Sawyer and Man had then ceased to be joint inventors. The testimony is that the habits of Mr. Sawyer were such that Man was unable to endure them, and in 1879 a meeting of their organization was called at which it was decided to go out

of business for the reason stated. They do not profess to have done any inventing after March, 1878. If there is any invention in this lamp, it was Mr. Edison who first gave it to the world. The means of making a perfect vacuum did not come from him, but nevertheless did not exist prior to 1878.

Such being the state of public knowledge he would now consider the testimony of certain witnesses. Mr. Lowrey then read a letter of Sawyer's in the *New York Herald*, December 31, 1879, claiming priority of invention in the horseshoe lamp, but stating that it was so complete a failure that it would be wasting money to spend $35 for a patent on it. It is quite possible that they made a horseshoe lamp, but he did not think they bent it in a particular shape for a particular purpose. It was an abandoned experiment, and its resurrection from the grave of failure was falsely and fraudulently brought forward after the publication of the Edison discovery and of Sawyer's letters with the view of establishing a negotiable claim and compelling recognition from Edison. These people had seen what was at Menlo Park, that it was a better thing than they had, and thereupon was begotten the unholy desire to invent what they had seen there. Sawyer was a man of ideas, of mechanical expertness, a "smart fellow." Mr. Man, a lawyer, a collector of rents, to whom the study of electricity appeared a pleasant evening's occupation. In 1878 Man started out in expectation of great rewards in efforts to be made by him and Sawyer as joint inventors. He tells us he expected to produce a first rate practical incandescent lamp in a month. Now they say that they made this lamp and other devices, but did not apply for patents until October; that owing to the inebrious indulgences of Sawyer they were unable to complete the application. It was only after the publication of Edison's discovery that they could get Sawyer away from intoxicating drinks and procure his signature to the application. In Man's testimony their Honors would find the statement of what these gentlemen were seeking to achieve and how they supposed they had done it. They conveyed a piece of carbon into a glass globe, having excluded as much air as they could, and raised the carbon to incandescence. Edison says that until he had seen 100 lamps break down under the current he could not tell whether they were practically useful or not. But these gentlemen only wanted to know "such carbons could be used." Of course they could; but bearing in mind that results obtained with one lamp would in no wise be conclusive as to anything, the test will appear in all its utter feebleness and inconsequence.

Mr. Lowrey then read from Sawyer's testimony his opinion that a lamp which would burn from 5 to 100 hours could not be used in competition with gas, and from the testimony of Mr. Broadnax that they could not get an effectual vacuum. Edison believed that the difficulty lay just here, when suddenly occurred the idea of sealing up the whole thing in an air-tight glass globe, and he said to himself, "Now we have what we want."

Mr. Lowrey next referred to the decision of the Examiners-in-Chief of the Patent Office and the testimony of Sawyer, referring to a publication made by Sawyer challenging Edison to maintain a vacuum in his lamp and to run his carbonized paper lamps three hours. Thus it stood on December 22; but on January 9, a different light had shown on the subject and they decided to apply for a patent. By way of showing that the lamp was an operative one, a witness has been produced from Pittsburgh and another from New York, to prove that they had set up these lamps and burned them for some time. They proved nothing which was even interesting.

Now, if the Court pleased, this was a case of two inventors and two lines of invention. The lines upon which Mr. Edison proceeded were scientific and thorough; the lines upon which these gentlemen proceeded were not. The lines they were pursuing were series lighting and low resistance; the lines pursued by Edison were upon opposite principles, and resulted in this lamp which made its apperance in 1879. Within two days appeared Mr. Sawyer's denial that such a lamp could be maintained. Within 10 days appeared the patent claim which has been amended until at last it stands as interpreted by the experts upon this basis:—You must not do this because in 1878 we used paper. We now say paper is a fibre; bamboo is also a fibre. You must not use it because we have marked across the face of this substance, paper being a vegetable fibre and having been used by us, nobody else can use it. If that were permitted to prevail it would be the most marked instance existing in the patent law of a successful attempt to bar the course of invention to appropriate in advance what might be done by useful effort, and that for the benefit of them who never gave anything to the world except a name and a claim.

ARGUMENT OF RICHARD N. DYER.

Mr. Richard N. Dyer then commenced his argument for the defense. Part of the duty, he said, that had been assigned to him, was a statement in detail as to the state of the art as proved by the record. He hoped when he had finished that their Honors would reach the conclusion that it was not the selection of material or the particular form of burner which was required to make household electric lighting a success, because both the material and the form were old, but that it required the introduction into the art of a new principle, original with Mr. Edison and entirely unknown to Sawyer and Man. Mr. Dyer then proceeded to give a history of the art of incandescent lighting, beginning with the discoveries of Volta and of Sir Humphrey Davy, taking up one by one the various patents and publications; King in 1845; Staite, 1848, who showed an arch-shaped burner of platinum; Shepard 1850, Gardiner and Blossom, and others. He then referred to the experiments of Violette, in *Silliman's Journal*, 1853, and of Sidot in *Comptes Rendus* in 1870, who carbonized various fibrous and textile substances. In view of these publications, said Mr. Dyer, we find that in 1872 the art was provided not only with lamp structures more or less perfect, but with the early investigations of Davy as to producing arc and incandescent lights with carbonized fibrous vegetable material and with the later investigations of Violette and Sidot with modified forms of carbonization. In the patent of Konn, 1872, is shown a V-shaped conductor of carbon, which, he contended, was equivalent to the arch shape and which had a chamber entirely of glass. This was admitted by Professor Houston, complainant's witness in a suit upon this same patent in New York. It was, therefore, settled by the record that the Konn patent shows the arch shape in carbon, as the Staite patent showed the arch shape in metal.

Mr. Dyer then took up the question of the insufficiency of the description. He said the description is not sufficient, it is too broad, it includes the entire vegetable kingdom for which only a very small portion is suitable for the purpose. The entire description of the carbon contained in the first application is "we have tried various things." Mr. Pope's attitude is that charcoal, broadly speaking, is carbonized fibrous material. He says, the mere mention of paper is sufficient to support it. Dr. Morton sustains the position. Mr. Dyer in conclusion said:—If paper is what is to furnish the essential condition for this invention, we say that paper furnishes no such indication. The coating of carbon by the use of materials like plumbago does not entitle them to a claim for paper. Dr. Morton says the reference to plumbago means one thing, Mr. Pope says it means another thing, Professor Houston another. Now, in opposition to this, we show you what it does mean. It means carbonizing by means of a current; The complainants would, therefore, contend that the original specification in which the invention must be found is entirely deceptive.

ARGUMENT OF AMOS BROADNAX.

At the morning session, Thursday May 23d, Mr. Amos Broadnax continued the argument for the complainant. Mr. Broadnax said that in continuing where Mr. Dalzell left off, he would call attention once more to the claims of the patent. The first claim was for an article, a thing of fibrous or textile material in the shape of an arch or horseshoe and intended to be used in an electric lamp, and that thing is entirely irrespective of the kind of lamp in which it may be used. The invention is the same in our lamp, in the Edison lamp, in the bell-jar of the vacuum pump or in anything in which it may be burned. The second claim is for the combination of three elements, an electric circuit, an incandescing conductor of textile material or fibre, forming part of said circuit, and a transparent hermetically sealed chamber. The third claim is for an incandescing conductor of carbonized paper; and the fourth for a combination of a hermetically sealed illuminating chamber of glass out of which all carbon-consuming gas has been exhausted or driven, an electric circuit conductor passing through the glass walls of said chamber and hermetically sealed therein, and an illuminating conductor of carbon made from fibrous or textile material, having the form of an arch or loop. Their Honors would observe that the last claim embraced the essential elements of an incandescent lamp, all these elements being old, excepting the incandescing conductor of fibrous or textile material in the form of an arch or horseshoe.

The first question was: When did Sawyer and Man make the invention of these several claims and reduce them to practice within the meaning of the patent law? He claimed that these inventions were first made and used by Sawyer and Man in the spring of 1878, and had been continued in use by them or their assigns in one form or another from that time to this.

Mr. Broadnax then proceeded to read extracts from, and to comment upon the testimony of the several witnesses called by complainant, from which it appeared that the use of paper was first suggested by the carbonization of paper which was employed as a convenient receptacle for a line of powdered graphite. This led to the carbonization of strips of paper in a closed iron vessel. Carbons thus made were brought to incandescence in globes filled with hydrocarbon gas. These experiments were made in March, 1878, and from that time forward Sawyer and Man were continually experimenting in the manufacture of fibrous and other carbons, in the treatment of carbons, and in the constructions of lamps. A great variety of woods were carbonized. These carbons were of various shapes, straight, arched and V shaped. They also conducted a large number of experiments in the construction of the lamp, its sealing, its atmosphere and its leading-in conductors. Most of the carbons were subjected to what is known as the hydro-carbon treatment, which was invented by Sawyer and Man, March, 1878, and patented the same year. Concerning

the atmosphere of the lamps, they first used illuminating gas, then hydrogen and finally nitrogen, which proved the best. Before they left the Centre street shop, June 1, 1878, they had incandescent lamps which would run for hours, days and weeks. Such a lamp was put in evidence in the interference case to refute the statement made by Edison, that Sawyer and Man had not produced an enduring incandescent lamp, having a carbon illuminant in nitrogen, and that it was impossible to make such a lamp with a cement sealing. On October 15, 1878 they moved into a shop at the corner of Walker and Elm streets, which they vacated in March, 1879. Here they perfected their fibrous carbons, used them in their lamps and exhibited them to a great number of people. Nearly all the lamps made and used by Sawyer and Man had enclosing globes made wholly of glass. Some made in the spring of 1878 had an enclosing globe wholly of glass in one piece. The testimony of Man is fully corroborated by the testimony of William E. Sawyer, William Sawyer, T. B. Stillman, Lawrence Meyers, W. H. Church, Mrs. Ives, and others.

Mr. Broadnax then took up the letters said to have been written by Sawyer to the *Herald* and *Sun*. He contended that the statements of Sawyer were entitled to no weight, both by reason of his inebriate condition, and because he was then engaged in an effort to destroy the patents, which were then owned by an opposition company. In the spring of 1879 the company owning the patents discontinued its work on account of the bad habbits of Sawyer, who was dismissed. He became hostile, applied for and was refused a license under the patent, whereupon he became the bitter enemy of the company, doing all he could to injure, belittle and destroy this patent, and so effective was his opposition, that the company on April 6, 1881, sold out to the Eastern Electric Company, the opposition corporation which Mr. Sawyer had organized. Were Mr. Sawyer's testimony, letters and books eliminated from the case altogether, it was supported by the testimony of ten or twelve witnesses and corroborating circumstances upon all the essential points, which was surely sufficient. The rule is well settled that an assignor cannot admit or declare away the rights of his assignee. The evidence conclusively proves that Sawyer and Man not only conceived, but reduced to practice, the invention covered by each of the four claims of the patent, in the spring of 1878.

Mr. Broadnax next took up the history of the interference case in the patent office, and showed that, although the issue referred specifically to paper carbon, the proofs showed that the first fibrous carbons employed by Edison and by Sawyer and Man in incandescent lamps were of paper; and, therefore, the decision in effect determined that Sawyer and Man were the first to make an incandescent conductor, not only of paper, but of any fibrous or textile material. He quoted from Edison's testimony in the Swan interference, in which he said: "The main thing that was in my mind was a lamp made of a filament of carbon, independent of the particular quality of material or cellulose used; and, as the experiments of 1877 as to the electric lamps were failures, they did not impress me one way or the other, *certainly not as to material.*" Mr. Broadnax then showed from the testimony of Edison and his assistants, Upton and Batchelor, that Edison's invention was conceived and perfected in the fall of 1879, Mr. Edison saying that it was in September or October that he "first reached the conviction that electric lighting could be successfully accomplished by the use of carbonized paper in high and stable vacuo." What Mr. Edison's theories about fibrous carbon may have been is nothing to the purpose. The questions are, what did he do, and when did he do it? It does appear that he did make, and successfully use, a fibrous carbon conductor in his lamp; but it does not appear that he did it before October, 1879, one year and a half after the same invention had been made by Sawyer and Man.

The statement that he could not sooner make the fibrous carbon lamp for want of an efficient vacuum pump is entirely without foundation, for it appears by defendant's exhibits that the Sprengel pump was known in 1874, and was used by Crookes for obtaining a high and stable vacuum in his radiometer. There was nothing more to prevent Edison from using it in 1877 than in 1879. The fact is, Edison never used carbon of any kind in a lamp before the fall of 1879. The proofs show that all the lamps made before (and they were very numerous) had metal conductors. Sawyer and Man, on the other hand, never made an illuminant of metal, or anything other than carbon. They were satisfied from the first that that was the proper material, the only question was which kind was best, and what was the best way to make and use it. They were constantly studying the properties of carbon of every kind they could make or obtain. They had made lamps of fibrous carbon conductors that ran days and weeks before Edison made one of any kind of carbon which would last ten minutes.

Mr. Broadnax closed by a brief consideration of the question of priority of invention of the combinations in the second and fourth claim, and showed from the testimony that none of them had been invented by Edison prior to the fall of 1878.

ARGUMENT OF BENJAMIN F. THURSTON.

Mr. B. F. Thurston then proceeded to make the closing argument for the defendant. He said the theory of the plaintiff seems to be that, having invented, as they say, the employment of a fibrous carbon in an incandescent lamp anterior to the time when such carbon was used in a similar lamp by Edison, therefore they are entitled to claim fibrous substances generally as carbons in incandescent lamps, and to hold the defendant tributary thereto, notwithstanding it is admitted in open court that the third claim of the patent in suit, which relates to the only fibrous carbon that they ever made of paper, is not infringed by defendant. He should address himself particularly to the material questions of law arising upon the face of the patent. He should contend that the facts, even if in favor of the complainant, were utterly immaterial for the right decision of the case. The problem that confronted the electrical world until the fall of 1879, when it was solved by Mr. Edison, was that of utilizing the electric current in economical competition with gas—the subdivision of the electric current. The difficulty was the expenditure of money involved unless it could be economically divided. He wished their Honors to carry in mind that Mr. Edison, in November, 1879, applied for a patent, granted January 27, 1880, prior to any matter in controversy here—the patent which solved this problem. It is spoken of, and properly, as the filamentary high resistance carbon patent. He did not propose to discuss this patent, as it was not in issue. Its characteristic was the employment of a filamentary or thread or hair-like carbon as distinguished from the substantial conductor, whether of carbon or other material, fibrous or amorphous, known before its date. It is the difference between a carbon 6-1000 and a carbon 1-32 of an inch diameter. He adverted to it to show that the thing to be accomplished was the problem stated, and he asserted that it was accomplished by the means set forth and the inventions specified in that patent. No question has been made that any other person conceived and executed the idea of employing a filamentary conductor, but it has been invaded; it is used by the complainants, and by all. It has not undergone investigation in the courts of this country as yet.

Now, the Edison filamentary carbon is of vegetable fibrous material—bamboo, and hence complainant says that because paper is in fact fibrous, it embraces bamboo and the whole vegetable world. That is the proposition their Honors are asked to determine. What will be the result? If the plaintiffs can maintain their contention, the use of the filamentary carbon of fibrous vegetable material must be inhibited, and the real solution of the problem, to Edison and all others, must stop in its practical application for the uses of man. On the other hand, the complainant, if Edison's patent be good, would have no right to use carbon in filamentary form; and thus, if both inventions are to stand, the world must be in darkness again, as it was before 1877, so far as any illumination from the electric light dispels that darkness!

He proposed to consider in this branch of the discussion three questions: *first*, what was the invention set forth in complainant's patent as filed? *second*, what were the steps attending its evolution into its present form; and *third*, is the subject-matter of fibrous carbon, as distinguished from hard carbon, a legal subject of claim? The real contest here is the subject of invention claimed by the complainant; whether they are entitled to appropriate to themselves the exclusive employment of a fibrous material of vegetable origin as the base of a conductor in an incandescent lamp. The only thing upon which their opponents relied was that their Honors would favorably consider this, as they say, their novel subject of invention, the introduction into an old lamp of a carbon, the base of which is fibrous vegetable material, and that conclusion is to be reached from evidence that Saywer and Man were the first who actually carbonized and manufactured the article known as paper. He would show their Honors that the application, as originally filed, was intended purposely to cover and embrace the only subject of invention that these parties pretended down to 1885 that they made—the arched form—and nothing more. Turning to the original specification, he said that the first, second and third claims all contained the limitation to the form of the carbon; observing that though the fourth claim was for an incandescent arc of carbonized fibrous or textile material, there was not the least foundation in the specification for its support. Their Honors would perceive that, on February 28, 1885, the invention was, by amendment, enlarged to cover all carbon derived from a vegetable base, intending thereby broadly to claim the use of carbon in an incandescent lamp, and in this amendment they state various matters which are not true. For example, the statement that the lamp is made wholly of glass, was absolutely false. It is a jointed structure made of glass, in two parts, united by cement: the language, "wholly of glass," was intended falsely to be used in order to embrace Edison, and in that phraseology to sweep him into an infringement of the claim. Their Honors understood the rule of law of the Supreme Court, upon an enlargement of the specification for such purposes as I have declared this to be, during its progress in the office. He then quoted from the opinion of Justice Bradley in Railway Co. *vs.* Sayles (U. S. 554).

He now came to the third proposition. Does the claim express a proper and legal subject of invention? The fundamental principle is that no person can appropriate a law of nature, but only a means by which that law, the property of the world, is har-

nessed for the uses of man; so by analogical reasoning, no person can claim the exclusive use of the vegetable or the mineral kingdom, as such. Plaintiffs say: "We do not claim broadly the use of fibrous material; we have narrowed the claim, and have made it, so far as claim one is concerned, with the limitation to the arch form, and as to the second and fourth claims we have put it in combination with an electric circuit and exhausted lamp chamber." This is but a play on words. The essential thing, which if the contention of plaintiff holds good will be accorded him, is the monopoly of fibrous material when employed in an old combination.

(At this point there was an intermission of an hour.)

Mr. Thurston, resuming, said that he would suspend the discussion of the point under consideration before adjournment to consider another point not fully adverted to in order, which was that the Sawyer and Man structure of 1880 was worthless as a commercial article. Comparing their lamp of that date with that containing the invention he had assigned to Edison, the question whether the latter can be made tributary to the claim of Sawyer and Man depends upon whether their device in 1880 was of any practical value. He asserted that it was not.

Their Honors would find by the record that low resistance lamps were incapable of use in multiple-arc because of the prohibitory cost. Mr. Pope says a series system as distinguished from a multiple-arc system would be of limited application. We are to view this matter as it was in 1880. The Sawyer-Man lamp was intended to be used only in series. If it be true, as the record establishes, that all Sawyer and Man practically did was worthless compared with that which Edison did, which has continued to be successful to this hour, then, indeed, the question of identity of invention is in the eye of the law very easy of solution.

Returning now to the interrupted discussion of the first claim of complainant's patent, the emphasis necessarily is on the arched form, therefore, if in the prior art the same form was employed in platinum or iridium, then the claim illustrates merely double use, and constitutes no invention, unless indeed there be some peculiar quality, different in kind, which results from giving the arched form to the carbon. There is not the least foundation in the specification for any such difference in kind. In the amendment of 1885 certain advantages are stated for using the arched form whether of iridium, platinum or carbon; undoubtedly, though the specification does not say so, it enables a flexible or pliable material to stand a strain better than if not arched, but that is so in every arch. All the advantages of the arch form existed in the arch. Hence, he contended, as an elementary proposition, that it was a proper and perhaps a happy selection, but beyond that of no importance; a difference of degree and not of kind.

As to the second and fourth claims, the same arguments applied. His proposition was that if there were existing in a prior lamp of incandescent type a carbon either hard or fibrous, there could be no subject of invention in the arch form. He would address himself directly to the line of argument that his brother Wetmore would probably take, but which he thought was fallacious. The suggestion was this: admitted that fibrous carbons were old in arch lighting, is it not a substantially different thing to employ the same carbon in an incandescent lamp, and may not he who first used it and made a patentable invention? He thought not. The uses and necessities of carbon in arc lighting were undoubtedly different from those in incandescent lighting, but it was known before either of these parties entered the field that in an incandescent lamp carbon must be burned either in vacuo or an inert atmosphere; the resisting capacity of carbon compared with platinum was also perfectly well known in the art; it was not discovered, in a patentable sense, in 1880. In support of this proposition he would refer to the decision of Justice Blatchford in the Celluloid case, and the decision of the Supreme Court in Cohen *vs.* the U. S. Corset Co. He further contended that if prior patents used the terms carbon or charcoal, words of general signification not excluding fibrous material, then they were authorized, and the law was bound to infer, that it was a publication sufficient to instruct all coming time as to the employment of such material. He even went further, and would say that there had been actually fibrous carbon used. He insisted, therefore, that the true construction of the claim should impose the limitation to carbonized paper and wood charcoal, and that the words "fibrous and textile material," as signifying any broader expression than those materials disclosed in the specification, should be qualified accordingly. The point would be found in Goodyear *vs.* Davis, 102 U. S., and Benne *vs.* Gentet. The bamboo used by the defendant was a material different from any indicated, suggested or hinted at in the specification. It belonged to the vegetable kingdom, but there the identity ended. The only thing upon which any success is claimed is the carbonization of paper, a manufactured product. Bamboo was as much a different material, as completely a new discovery with reference to its utility as a conductor, as was celluloid in comparison with vulcanized rubber. Moreover, the Patent Office had given Mr. Edison a specific patent for bamboo fibre as the base for a carbon conductor.

He would submit to their Honors that the protection by patent must rest on the specific discovery, and not upon the inclusion of things undiscovered at the date of the patent by intendment. Perhaps the other side was misled by a fallacious suggestion from the law of combination of the mechanical elements, which are very few and have been known from the earliest ages. It was very different when one entered the undiscovered country of chemistry and explored the vast secrets yet to be revealed. He would remind their Honors of the doctrine announced in the Supreme Court case of Cochrane *vs.* Badische Anilin & Soda Fabrik, 111 U. S., 293. The claim was broadly for alizarine, but the court limited the invention to the employment of bromine, although in its relation to the useful arts, it was one of the most brilliant discoveries that ever occurred to man, almost the first instance in which by chemical processes man was able to arrogate to himself, in the creation of a new thing, almost the functions of the Deity.

Referring to the interference proceeding, he would ask their Honors not to indulge for one moment in the belief that anything decided in the interference affects this case. It was declared between these parties, but not upon the subject-matter which is the foundation of the Edison lamp. It was simply the question who first used the specific thing—paper. (The Court here remarked to Mr. Thurston that he need not trouble himself to discuss the question as to the interference decision being *res adjudicata.*) Mr. Thurston, continuing, said that complainants founded themselves upon an inference, namely, that they are entitled to hold all fibrous material because they first used paper carbon in an incandescent lamp; that the discovery of the fitness of one of the species covers the whole species, without regard to whether any other of the species is fit or not. In his view, if the fact were removed upon which they sought to found this absurd inference, their case is absolutely lost. But he would go further. He would ask that their Honors read the opinions of the Examiner of Interferences, the Board of Examiners-in-Chief, and the opinion of the Commissioner, upon the subject. To the opinions of the Examiner and of the Commissioner, adverse to Edison, he would enter a general demurrer, and ask their Honors in their opinion on the facts stated to hold that they were wrong. He contended that Edison came under the defense in section 4,920, viz:—that another had unjustly obtained a patent for that which was in fact invented by one who was using reasonable diligence, that special defense being pleaded in the answer.

It having been shown that before the supposed invention of Sawyer and Man the properties of fibrous cellulose in electric lamps were well known; also that the conductor should be in an hermetically sealed chamber; also that the arched form could be used, it constituted no invention in 1879 to apply a carbon of fibrous material, in an arched form, in a chamber from which air had been excluded. Every such invention must stand on some particular carbon, method of preparation or quality of construction—as for example, the filamentary characteristic—or the discovery of some new material particularly adapted for the purpose of a carbon.

What was the virtue of bamboo carbon? The testimony of Edison and of Professor Wilson shows that not one out of ten thousand, or of twenty thousand, of the fibrous organizations in the vegetable world are fitted for carbons; not a single one, he believed—but to be safe, he would say very few. Fibre is not the controlling thing. It is a question of a suitable material existing in nature possessing qualities, one of which is that of having fibre, but without other qualities it would be worthless. He asserted that the result of this investigation on the part of Mr. Edison was to make a grand discovery. He it was who solved the problem of practical electric lighting by incandescence. Whatever the defects in his patents, whatever the misfortunes of his position in reference to law of his not claiming them properly, or of his forfeiting them, the memory remains, and will remain for all time, of his having introduced the art of electric lighting.

ARGUMENT OF EDMUND WETMORE.

Mr. Edmund Wetmore made the closing argument for the complainant. He said that he should attempt no more than to state briefly the conclusions of fact which the record showed, and which contained the answer to the defenses presented by his brother upon the other side. He was aided somewhat in that task, because, in his view, very much which had been said was not relevant; he said this, not by way of disparagement, but in explanation of his omission to refer to many things which it would otherwise have given him pleasure to answer. We are here, said Mr. Wetmore, with a patent which bears the presumption which the law allows it. The burden of proof lies upon the defendant to defeat it; the burden of proof lies upon us to prove infringement. Confining himself to these issues, he would proceed to a consideration of the only defenses presented in the argument: 1, that defendants have not infringed; 2, that the issued patent was unlawfully expanded; 3, that Edison anticipated the invention; 4, that the thing described is inoperative; 5, that the specification is not sufficient; 6, that the patent is void, because of anticipation; 7, that in view of the state of the art it is void for lack of patentable novelty. He would say a few words applicable to each of these defenses. Much had been said which was presumably deemed relevant, in laudation of Mr. Edison, who had just

been eloquently described by his learned brother as the inventor of the entire thing, the father of incandescent lighting. Now, while he would in no measure detract from the very great merits of Mr. Edison as a contributor to the art of incandescent lighting and other electrical arts, the record shows that he is not entitled to the extravagant pretensions made for him in that behalf in this case. On the other hand, his brother Lowrey had spoken with undisguised contempt of the inventions of Sawyer and Man, apparently seeking to derive an inference that their lamp could not be expected to work; that they were amateurs and dabblers merely. One word as to what the record showed those gentlemen to be. Mr. Albon Man, of New York, was one of the oldest and most respected members of the bar, not a "rent collector," but a lawyer of long standing, holding positions of trust in connection with estates amounting to millions of dollars. During a well-spent life he had sought useful recreation in the investigation of science. He was associated for the period of one year with William E. Sawyer, a man whom this record justified him in saying was possessed of mechanical inventive genius, but, as so often the case with genius, it was in Mr. Sawyer's case accompanied by an unfortunate infirmity, which should be a matter rather for pity than for ridicule. These two men worked in a little shop, which the moderate means of one, and the absolute poverty of the other, enabled them to occupy. They did not have at command the greatest laboratory of the world, with the wealth of all Wall street behind them. They had to buy from the shops the bamboo, which, among other things, they used in the making of their fibrous carbon, instead of sending to the centre of Africa or the jungles of the Amazon, and yet, within that twelve months these gentlemen contributed a series of useful and brilliant inventions to the art of electric lighting scarcely equaled by any inventor during the same period.

The patents which embraced these inventions are in this case. From that day to now they have been universal and essential in the art of incandescent lighting. The hydrocarbon treatment, described by Professor Cross as a most beautiful discovery, one in universal use to-day in every lamp factory, I do not except even that of defendant; the process of dispersing occluded gases; the safety-fuse for the incandescent lamp, without which not a single plant would be permitted by the insurance companies to be installed or the current carried into a house. These are the gentlemen who are sneered at as having contributed nothing to the art of incandescent lighting. What did they contribute? It is a singular fact that the art of arc lighting was taken from the laboratory and became practical with the discovery of a suitable material from which to make the conductor, to wit, hard retort carbon, by Foucault, in 1845. So the art of incandescent lighting first became practical after the discovery by Sawyer of a suitable material out of which to make the conductor. Now he would not imitate the reasoning of defendant, and say that, if Sawyer and Man did not invent the incandescent light, neither did Edison. It was the joint product of many inventors, proceeding step by step. He would say that, long as were the series of steps to be taken, there was no contribution to that art of greater value than that made by the patent now in suit.

Incandescent lamps had existed for 40 years. No one had used carbonized fibrous or textile material for a conductor in such lamps. Sawyer and Man filed in the Patent Office the statement, "to make a good conductor for an incandescent light, select carbonized fibrous or textile material." The Office made it known to the world. From that time to this no incandescent lamp of any description, of high resistance or low, has been made or sold, the conductor of which was not made of carbonized fibrous or textile material, the material referred to in the patent in suit. They claimed, therefore, a conductor of such material; a claim based upon the fact that the world had never before observed nor availed itself of the peculiar adaptability of that material. They went one step further; the material was of a peculiarly fragile nature, and they made the simple discovery that the breaking of this fragile strip may be prevented by bending it into an arch. And what has been the consequence? From that day to this there never has been, of high resistance or low resistance, any incandescent lamp illuminant that has not had that arch form, and been composed of that material. Having made that invention, it was their duty to describe it, and all they needed to state was: "if you want a good conductor for the incandescent light, make it of carbonized fibrous or textile material, put it in an arch form, and you will obtain an advantage not heretofore obtained, a new and useful result." His friends of other side held that this was a mistake; that the material and shape is of little consequence; that the whole problem was in the discovery: first, of multiple-arc distribution; and second, that the conductor must have a high resistance and small radiating surface. Mr. Wetmore then proceeded to explain the difference between the absolute and the specific resistance of the conductor, and contended that to bring the resistance to the point needed was a mere matter of construction, it was one of the elemental facts known in the art, and in reference to its application for electric lighting, he referred to the English specification of Lane-Fox of 1878. But, even supposing Edison the first discoverer of that fact, which he was not, it would not be material to this case. Whether the absolute resistance of the lamp is to be low or high, it is a distinct advantage to have high specific resistance in the substance of the conductor; and one of the advantages of fibrous carbon was its high specific resistance in any form, and, therefore, its large light-giving capacity. He would not attempt here to enter into a complete explanation of the difference between multiple and series lighting; both have advantages, and both disadvantages. In answer to a question from the Court, Mr. Wetmore said that series lighting was in use, and long had been. He exhibited lamps of low resistance made by Bernstein, Edison, and others. If their Honors would look to-night in the direction of the Monongahela bridge, they would see it ablaze with incandescent lights burning in series. It has always been a useful and operative system, and any lamp fitted for that system was a lamp of high utility. His attention was this moment called to the fact that the resistance of *that* lamp (indicating an Edison lamp) is only about one and a half ohms. Edison states that 100 is necessary.

Referring to the point of infringement, Mr. Wetmore said that this patent had had absolutely nothing to do with the dimension of the conductor, nor with the question whether the lamp in which it was used happened to be a lamp of high or low resistance; the useful thing is the carbonized fibrous or textile material, its fragility corrected by putting it in the form of an arch. In answer to a question from the Court, Mr. Wetmore said such fibrous material as any intelligent man familiar with the art would select, would answer the purpose. Referring to the application, he said that the law requires, *first*, that the party shall have done the thing specified, and *second*, that he should describe it in such a full, clear and accurate manner that everybody else skilled in the art can comprehend what is meant. He is not required to explain the theory of his invention, nor its advantages. The patent addresses itself to those skilled in the art of dealing with such materials as are specified. It says, in effect:—"If you would select the material most suitable as a conductor, you must select a carbonized fibrous or textile material." The next advantageous device is the beautiful one of the arch to correct fragility. Whether or not the specification states the advantages of the arch form is immaterial. In order to get your best conductor you select carbon of this character and put it in an arch form. He claimed that that was sufficient. Referring to the amendments and corrections, Mr. Wetmore said that they were largely upon the suggestions of the Patent Office, and were perfectly good corrections. He could not understand how his learned brother could say that the original application had been expanded. The arch shape was certainly described, and so is the textile material. The law that his learned brother referred to in the Tanner brake case, is simply the law that governs all correct practice, that nothing can be added to the application. Nothing *had* been added. Nothing except the insertion of a few verbal improvements in the direction of distinctness and by way of limitation, not only lawful, but suggested by the Patent Office. He would say a word in answer to his learned brother as to the alleged anticipation by Mr. Edison. The assertion was that in 1877, Edison conceived the idea that what was required was a conductor of suitable material in good stable vacuum, but the state of the art did not permit of the procurement of such a vacuum; what he was waiting for was the Sprengel pump, the identical thing with which he made his vacuum when he got it. It was well known in the art. It was just as possible for Mr. Edison in 1877 to make a vacuum as it is now, as their Honors would see from the description in the *Philosophical Transactions of the Royal Society*, 1874 and 1876. He would call their Honors' attention to the testimony of Mr. Broadnax, the solicitor to whom Mr. Man brought this invention in the summer of 1878, for the purpose of drawing the application for a patent. He discussed with Mr. Man the patentability of a conductor of fibrous or textile material. Mr. Man had from the beginning regarded this as the solution of the problem. Mr. Sawyer was less enthusiastic and had his doubts. The argument that this substance was a substitute, indisputably proved that it belonged to a period anterior to its publication as a discovery by Mr. Edison.

He would now pass to the next defense, that of inoperativeness. It had been repeatedly stated that this was not a commercially successful lamp. It is true that it never went into commercial use; but to maintain this defense it must be shown that it is not good for any purpose whatever. Wherein consists the inutility of the lamp? They do not pretend that the conductor will not work. They say the lamp could not burn long enough to compete with gas, first, because if you preserve the identical dimensions shown in the drawing, you can only use it in series lighting. True. The precise thing shown in the drawings is adapted to series lighting, a highly useful purpose. Then, they say the lamp would not burn a sufficient length of time. They never tried it. It was guess work. Their point is that you cannot get as perfect a vacuum with a joint as without a joint; but they failed to prove that fact. Complainant's witnesses say that the Sawyer and Man lamp will stand a vacuum or an atmosphere of attenuated nitrogen to burn at least 150 hours. That is a useful lamp; a highly useful lamp.

But it did not seem relevant to this case whether the vacuum obtainable was one that would last 10 hours or 10,000 hours. The

invention of Sawyer and Man is the substance carbonized. If it was good for the less perfect lamps of those days, and subsequent inventions have made a better lamp, and this same substance has adapted itself to the improvements of science, he would like to know what greater tribute could be paid to its merits.

Next, as to the question of its commercial success. The best incandescent lamp now made cannot compete with gas in point of expense. Not yet, although from 1880 until now a flood of improvements have poured in by the efforts of numerous inventors, has incandescent lighting been able to compete in price with gas. Was ever a single telephone sold in the form in which Bell made the invention? Does the fact that the first locomotive made could hardly have competed with horse-power, have any bearing upon the plain fact that it was an operative and useful machine? Can you take that conductor of carbonized fibrous and textile material in the form of an arch, suit its dimensions to the form of lamp in which it is to be used, and use it? The answer is, not one single incandescent lamp has not had put into it a conductor of fibrous or textile material in an arched form, and of such dimensions as are adapted to the system in which the lamp is to be used. The direct proof that this is an operative structure is overwhelming and contemporaneous. It was used. It was burned, and the only way its operativeness could be shown was to make an exact copy of the specification, and prove by witnesses that they had not used a single instrument or tool or thing not known to the art in 1880 (Mr. Wetmore then handed up to the Court a number of lamps constructed in accordance with the patent.) Mr. Wetmore then took up the third defense,—insufficient specification and anticipations. He referred to the amended specification of Edison, which the Commissioner of Patents refused to put into interference with the patent in suit. Mr. Edison, he said, occupies this position:—He has sworn that he is an inventor of the precise invention contained in the three claims in suit in the identical thing in which they are claimed. He has likewise sworn, as he is obliged to, that the specific description to which they are appended, containing no reference whatsoever to any fibrous or textile material except paper, is the full, clear and exact description which he is compelled by law to file, and which he swears is the proper one. He would contend that that position was inconsistent with his being heard, in the same suit, to say what he does say here, and still maintain that claim.

He would pass to the sufficiency of the specification. Professors Brackett and Barker enumerate what properties in general the material ought to have. Now, if that precise testimony were taken verbatim and put into the specification, it would not add one whit to what every electrician knew on the first of January, 1880. If you were selecting wood to form an arch, you would not cut it out of curly maple; every Yankee boy of ten years who carries a jack knife knows that he could not make an arch across the grain, and of course every electrician knew that in selecting material for the conductor of a lamp you must get one which is uniform in structure. It was amusing to hear the statements made; that this material bamboo, because it happened to be selected by Edison, was the only thing suitable, and that that was a great discovery on his part. He would be within limits in saying, that out of 25,000 incandescent lamps that would be lighted that night in Pittsburgh, there would not be 300 with a bamboo filament. At the great Westinghouse factory they were made of carbonized silk thread; the Bernstein company used silk thread; the United States company carbonized paper; the Brush company cotton thread, and because the Edison company think bamboo is the best, one would actually suppose that bamboo was the only fibrous and textile material that could be used for the purpose. Hundreds of thousands of lamps have been made of paper, of wood-carbon, of silk and cotton thread, the commonest textile materials. It was no criticism upon the specification that a skilled constructor, in making his selection of material, might submit it to a test. That the field is precisely as wide as they say, they had proved by going right and left into the field of fibrous and textile materials, carbonizing them and putting them into lamps. Here are specimens (handing them to the Court) palmetto, bamboo paper, Mexican grass, hemp, ash, linden, and so on. Nothing here not tested and actually burned on the circuit. Incidentally, in regard to bamboo, it had been stated that whatever else it was, it was not a textile material. Without sending to the Amazon, they had bought samples of bamboo weaving, proving it to be old in the art. And it appears in evidence that Sawyer and Man carbonized paper and wood, and every textile material that came to hand, and intending to represent those experiments in one comprehensive phrase, they said, "carbonized fibrous or textile material; your perfect conductor."

As to the question of anticipation; of course there can be no dispute that a prior patent or publication to anticipate a patent must describe the invention in sufficiently full, clear and distinct terms to give it to the world. The basis for the allegation that it was old to use carbonized fibrous or textile material consists in the fact that in three instances the word "charcoal" appears, and defendant's expert says it means wood-charcoal. We say that the context shows that it means in every instance hard carbon. A patent cannot be anticipated by holding an ambiguous word to be a sufficient description of carbonized fibrous or textile material. It would never have suggested to anybody the idea that such material was proper and suitable for the conductor of an incandescent lamp. No instance is shown where anybody ever applied the material in a lamp until this invention.

But his friends on the other side say, this is not, in view of the state of the art, a patentable invention. Why not? If a mere substitution, of course it is not patentable. That is not this case. His learned friend had said: would you inhibit the Edison company from using this magnificent invention of theirs, of the filament, by claiming this carbonized fibrous or textile material and thus seeking to cover their bamboo? No! We would not inhibit them; we would not only leave them the full use of that invention, but we would leave it to them in the very preferred form in which they said they wanted to use it, in the specification of Edison's patent No. 233,898 referred to by Mr. Thurston. They describe their great invention of the filament carbon, high resistance, and they give the material which they say is the preferred form, and it is made by preparing a putty-like mixture of lampblack and tar. Go on and use it. Complainants will not sue for lamps of that material. But after our invention had been made they substituted bamboo for that material. Now it seemed to him that this was a patentable invention. In the development of this art it has been one of the most valuable contributions. One of the most useful properties in all fibrous and textile carbons, is their susceptibility to hydrocarbon treatment, which makes it possible to use almost anything within the whole range of materials of that character.

In conclusion, whatever may be the eulogy to be given to Mr. Edison in the eloquent terms expressed by Mr. Thurston, he could in more sober and exact language claim for Sawyer and Man quite as high a place in this art as Mr. Edison is entitled to. "Whatever this defendant company, with its vast wealth and boundless resources, may have done, it has no right to come to our quarry to select the material from which to build its structure, and then contemptuously refuse to acknowledge our rights because it has altered the shape and dimensions of that material. We have a right to claim our property wherever we find it. They have no right to use that beautiful discovery that the fragile arch of carbon would not break, and ignore the discoverers. They have no right to change the material of their carbon filament and substitute that of the Sawyer and Man patent, and then refuse to recognize the patent, because their filament is longer or thinner than the particular conductor which the patentees showed in illustrating their invention. The complainants demand only that which the patentees invented—and for that they are entitled to a decree."

The arguments, which occupied three full days, were attentively listened to by a large audience. The Court reserved its decision, pending further consideration of the testimony and arguments.

THE EDISON "THREE-WIRE" PATENT SUIT.

In December, 1886, an action was brought by the Edison Electric Light Co. against Westinghouse, Church, Kerr & Co., electric light contractors, of New York, alleging the infringement by them of Edison's patent, No. 274,290, for a system of electrical distribution known in the art as the three-wire system. The plant complained of was one at Trenton, N. J., erected by them for the Westinghouse Electric Co., of Pittsburgh, of which a detailed description was published in the ELECTRICIAN AND ELECTRICAL ENGINEER of September, 1886 (page 337). The taking of testimony was commenced April 27, 1888 and closed March 30, 1889. The case was conducted by Messrs. Richard N. Dyer and Edward H. Rogers, of New York, for the complainant, and William Bakewell and Thomas B. Kerr, of Pittsburgh, for the defendant. The expert witnesses for the complainant were Professor Barker, of the University of Pennsylvania, and Professor Brackett, of the College of New Jersey; and for the defendant, Professor Morton, of Stevens Institute of Technology, and F. L. Pope. The case came to final hearing on May 8, 1889, before Judge McKerman, of the United States Circuit Court at Trenton, N. J. In their argument defendant's counsel did not appear to seriously question the validity of Edison's patent, but contended that it ought to be limited to the specific apparatus described, inasmuch as whatever was common to the system described in Edison's patent, and to that used by defendant, was old, and that, therefore, no infringement could be predicated. This view was, of course, strenuously controverted by the complainant's counsel. The decision, which has not yet been announced, will be one of much importance to the Edison company in its bearing upon the question of economical distribution from central stations. It seems probable that the patent will be held valid, the only question at issue in reality, being whether its scope is broad enough to cover defendant's particular apparatus, which was constructed under a patent granted to H. M. Byllesby, on July 6, 1886. The Westinghouse company discontinued the use of the plant complained of about two years ago, replacing it with their alternating system, so that in the event of an adverse decision their present interests will not in any way be affected.

INVENTORS' RECORD.

Prepared expressly for The Electrical Engineer, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions,* 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From April 23, to May 14, 1889 (inclusive).

Alarms and Signals:—*Burglar Alarm and Testing System*, F. H. Nutter, 401,789. *Annunciator-Drop*, J. M. Stuart, 402,043, April 23. *Bell*, I. Kinsey, 402,165. *Thermometric Indicator*, W. R. Patterson, 402,347. *Electric Signal*, J. T. Carter, 402,506. *Duplex Fire-Alarm Telegraph*, S. A. Chase, 402,507, April 30. *Electric Signaling Apparatus*, J. P. Coleman, 402,562. *Electric Bell*, W. K. Rainey, 402,613. *Electrical Annunciator*, B. Smead, 402,626. *Testing Apparatus for Fire-Alarms*, J. Young, 402,642. *Electric Bell*, R. R. Moffatt, 402,960, May 7. *Electric Alarm Clock*, T. H. Grady, 403,100. *Electrical Signaling Apparatus*, A. A. Hatch, 403,104. *Electrical Float-Signaling Apparatus*, J. R. DeMier, 403,180, May 14.

Clocks:—*Electric Striking and Repeating Clock*, A. M. J. & V. J. A. M. Jansen, 402,329, April 30. *Electric Clock*, E. G. Hammer, 402,823, May 7.

Conductors, Conduits and Insulators:—*Box for the Distribution of Electric Wires*, D. Brooks Jr., 401,927. *Electric Conductor*, T. Egleston, 401,936. *Splice-Box for Electric Cables*, T. J. Dewees, 402,007, April 23. *Insulating Cut-Out Joint*, H. M. & R. Doubleday, 402,420, April 30. *Method of Treating Underground Electrical Conduits with Chemical Substances*, A. E. Colgate, 402,563. *Conduit for Electric Wires*, G. W. Cook, 402,565. *Electric-Wire Insulator*, A. W. Heaviside, 402,592. *Insulator*, F. M. Locke and J. Lapp, 402,752. *Supporting and Cross-connecting Electric Wires*, W. J. Denver, 402,810. *Coupler for Electric Conductors*, G. I. Hopkins, 402,829, May 7. *Covering for Electric Cables*, E. F. Garland, 403,262. *Insulated Wire*, S. Heimann, 403,267. *Wire Cable*, T. C. Batchelor and A. Latch, 403,319. *Coupling for Underground Conduits*, W. Lake, 403,352. *Method of Protecting the Lead Pipe of Telegraph-Cables from Corrosion*, A. E. Colgate, 403,418. *Process of Electro-plating Lead Pipes*, L. D. Hosford, 403,429. *Insulating Tubular Iron Posts*, W. H. O'Beirne, 403,482. *Insulating Device for Line-Wires*, T. J. Smith, 403,491, May 14.

Distribution:—*Distribution of Electricity by Secondary Batteries*, G. B. Prescott, Jr., 402,190. *System of Distribution by Secondary Batteries*, same, 402,191. *Distribution of Electricity by Secondary Batteries*, same, 402,192. M. Pfatischer, 402,349, April 30. W. W. Griscom, 402,586. *System of Electrical Distribution and Conversion*, T. H. Hicks, 402,671. *System of Linear Transformers*, E. E. Ries, 402,971, May 7. *System of Electrical Distribution*, E. P. Thompson, 403,308, May 14.

Dynamos and Motors:—*Combined Motor and Electric Generator*, J. F. Shawhan, 401,761. *Dynamo-Electric Machine*, C. Coerper, 402,066, April 23. *Pole-Piece for Dynamo-Electric Machines*, J. G. Statter, 402,200. *Electric Motor*, F. Yeiser, 402,290, April 30. *Commutator-Brush Controller for Electric Motors*, W. L. Silvey, 402,990. *Automatic Governor for Electric Motors or Dynamo-Electric Machines*, S. S. Wheeler, 403,017. *Field-Magnet for Dynamos*, same, 403,018, May 7. *Dynamo-Electric Machine*, H. E. Walter, 403,158. *Dynamo Speeder for Gas Engines*, N. Rogers and J. A. Wharry, 403,376. *Dynamo-Electric Machine*, F. A. Perrett, 403,487, May 14.

Galvanic Batteries:—*Galvanic Battery*, R. J. Pratt, 402,104, April 23. W. P. Kookogey, 402,166, April 30. *Portable Galvanic Battery*, A. Friedlander, 402,915, May 7. *Galvanic Battery*, C. Colle, 403,253. *Electric Battery*, J. A. Barrett, 403,451, May 14.

Ignition:—*Electrical Gas-Lighter*, D. C. Knowlton, 402,332, April 30. *Igniter for Gas-Engines*, N. Rogers and J. A. Wharry, 403,380, May 14.

Lamps and Appurtenances:—*Incandescent-Lamp Socket*, F. C. Rockwell, 402,481, April 30. *Automatic Circuit-Controller for Electric Lights*, O. P. Loomis, 402,754. *Electric-Arc Lamp*, C. B. Noble, Reissue, 11,002, May 7. *Incandescent Lamp*, J. Stewart, 403,397, May 14.

Measurement:—*Electric Meter*, E. Thomson, 401,803, April 23. *Electric Meter for Alternating Currents*, D. L. Davis, 402,410, April 30. *Apparatus for Registering the Consumption of Electric Energy*, L. Brillie, 403,244. *Electrical Measuring-Instrument*, E. Weston, 403,311. *Portable Tangent Galvanometer*, same, 403,312, May 14.

Medical and Surgical:—*Electric Belt*, C. H. Grimley, 401,882, April 23. W. L. Van Dorn, 402,367, April 30. *Electrically-Controlled Apparatus for Treating Emphysema*, A. Steinhoff, 402,779, May 7. *Electro-Medical Apparatus*, T. J. Smith, 403,492, May 14.

Metallurgical:—*Magnetic Separator*, H. S. Maxim, 402,684. G. Conkling, 402,904, May 7. *Method of Reducing and Separating Magnetic Ores*, J. D. Cheever, 403,250. *Device for Collecting Metallic Ores*, H. H. Eames, 403,256, May 14.

Metal Working:—*Process of Welding Together Sections of Pipe by Electricity*, E. E. Ries, 402,107, and 402,108, April 23. *Method of Expanding Hoops or Tires*, M. W. Dewey, 402,416, April 30. *Apparatus for Coating or Galvanizing Sheet Metal*, E. A. Harvey, 403,044, May 7. *Method of Electric Welding and Shaping of Metals*, E. Thomson, 403,157. *Electric Riveting Apparatus*, E. E. Ries, 403,374, May 14.

Miscellaneous:—*Matrix-Plate for Curved Electrotypes*, G. H. Benedict and P. M. Furlong, 401,729. *Commutating Device*, D. W. Thompson, 401,801. *Process of Making Gas-Incandescents*, L. Paget, 401,898. *Gas-Incandescents*, same, 401,899. *Condenser Switch-Board*, W. Marshall, 402,027. *Message and Time Recorder*, J. C. Wilson, 402,120, April 23. *Electric Cut-Out*, J. L. Kimball and H. C. Wirt, 402,249. *Automatic Switch*, A. G. Lawrence, 402,252. *Magnetic Pocket-Book*, B. F. Thomas, 402,491, April 30. *Cut-Out*, O. P. Loomis, 402,753. *Rheostat*, J. B. Entrikin, 402,912. *Electric System of Communication*, E. B. Shafer, 402,986, May 7. *Electrically-Heated Vacuum-Pan*, G. B. and M. Johnson, 403,110. *Means for the Electrical Propulsion of Boats*, R. M. Hunter, 403,193. *Apparatus for Metallizing Electrotype-Molds*, S. P. Knight, 403,197. *Rheostat*, J. L. Gish, 403,345. *Gas-Engine*, N. Rogers and J. A. Wharry, 403,379. *Electric Controlling Device for Elevator-Carriages*, W. E. Nickerson, 403,439. *Electric Controlling Device for Elevators*, same, 403,440. *Electrically-Controlled Elevator*, same, 403,441. *Electric-Controlling Mechanism for Elevators*, same, 403,442. *Thermostatic Door-Closer*, W. R. Patterson, 403,484, May 14.

Railways and Appliances:—*Electric Railway-System*, S. H. Short, 401,796. *System of Elevated Conductors for Electric Railways*, same, 401,797. *Electric Motor for Tramway-Vehicles*, W. D. Sandwell, 401,970. *Compensator for Railway Signal and Switch Connections*, A. E. Mitchell and W. N. Stevens, 402,030. *Switch for Electric-Motor Trolleys*, W. Christy, 402,064. *Electric Car*, J. W. Henderson, 402,080. *Incline Electric Railway*, R. M. Hunter, 402,084. *Universal Upward-Pressure Contact-Arm*, C. J. Van Depoele, 402,117, April 23. *Safety Railway-Car*, C. C. Gilman, 402,157. *Electro Locomotive Engine*, S. Z. De Ferranti, 402,311, April 30. *Electric Railway*, R. M. Hunter, 402,832. *Insulator and Holder for Electric Railways*, B. Junnings, 402,836. *Electric or Cable Railway Car*, S. A. Bemis and L. Pfingst, 402,890. *Slotted Conduit for Electric Conductors*, C. J. Van Depoele, 403,009. *Electric Construction for Railway-Rails*, same, 403,010. *Electric Locomotive*, same, 403,011, May 7. *Conductor for Electric Railways*, L. Daft, 403,092. *Electric Railway*, R. M. Hunter, 403,192, May 14.

Secondary Batteries:—*Secondary Battery*, W. W. Griscom, 401,744. W. P. Kookogey, 401,953. C. Desmazures, 402,006, April 23. *Containing-Cell for Secondary Batteries*, P. Schoop, 402,484, April 30. *Time-Switch for Secondary Batteries*, C. E. Buell, 403,177, May 14.

Telegraphs:—*Printing Telegraph System*, C. J. A. Munier, 402,099, April 23. *Combined Telephone and Telegraph System*, W. Burnley, 402,298. *Telegraphy*, M. W. Dewey, 402,414. *Railway Telegraph*, F. J. Crouch, 402,408. *Telegraphy*, M. W. Dewey, 402,415, April 30. *Polarized Relay*, J. C. Wilson, 402,639. *Telegraph Instrument*, C. G. Burke, 402,717. *Circuit-Closer for Railway Car-Telegraphs*, G. I. Hopkins, 402,828, May 7. *Vibratory Telegraphy*, S. D. Field, 403,258. *Exchange System for Telegraphs*, J. H. Robertson, 403,291. *Combined Telephony and Telegraphy*, same, 403,292. *Printing Telegraphy*, Z. P. Hotchkiss, 403,472, May 14.

Telephones and Apparatus:—*Mouth-Piece Guard for Phonographs or Telephones*, W. K. Candee, 401,732. *Telephone Transmitter*, W. Gillett, 401,743. *Telephone*, E. A. Woelk, 402,121, April 23. *Multiple Switch-Board*, C. E. McCluer, 402,264, April 30. *Telephone System*, F. A. Holcomb, 402,928, and 402,929, May 7. *Device for Holding Telephones*, S. J. Adams, 403,316. *Multiple Switch-Board Testing Apparatus*, J. J. Carty, 403,458. *Testing Apparatus for Multiple Switch Boards*, J. J. O'Connell, 403,483, May 14.

EXPIRING PATENTS.

A Correction.

Washington, D. C., May 21, 1889.

In the list of "Expiring Patents" for May, 1889, furnished by me and printed in the May number of the Electrical Engineer, it appears that I reported those which lapse in May, 1893, through an inadvertence which to some extent, perhaps, was excusable, but which I am frank to say, was not unavoidable. The occurrence of the error seems to belong to Dundreary's category of "things which no fellow can find out," hence this apology. The patents reported by me as expiring in May, 1889, have four more years of vigorous life left, during which it is to be hoped that the patentees will obtain increased returns. The correct list for May is given herewith along with that for June.

F. B. Brock.

Patents relating to Electricity which become Public Property in May, 1889.

Reported for the Electrical Engineer, *by* F. B. Brock, *Patent Attorney* 639 *F street, Washington, D. C.*

Relays and Sounders, F. L. Pope, 126,486; *Printing Telegraph*, G. C. Wessman, 126,505; *Printing Telegraphs*, T. A. Edison, 126,528, 126,529, 126,530, 126,531, 126,532, 126,533, 126,534, and 126,535; *Key*, M. G. Farmer, 126,627; *Motor*, M. G. Farmer, 126,628; *Printing Telegraph*, P. Kenny, 126,714; *Electrolysis Apparatus*, W. T. Rickard, 126,744; *Indicator*, J. Unna, 126,761; *Duplex Telegraph*, J. B. Stearns, 126,847; *Gas Lighter*, J. Vansant, 127,000; *Fire Telegraph*, G. Floyd, 127,041; *Lightning Rod*, J. M. Mott, 127,094; *Printing Telegraph*, J. E. Smith, 127,111; *Burglar Alarm*, S. J. Hoffman, 127,165; *Electric Heater*, G. Robinson, 127,270; *Motor*, W. H. Richardson, 127,369.

Patents relating to Electricity which becomes Public Property in June 1889.

Clock, V. Himmer, 127,483; *Circuit Closer*, J. E. Smith, 127,809; *Motor*, J. Taggart, 127,810; *Fire Telegraph*, E. A. Callahan, 127,844; *Annunciator*, J. B. Shannon, 127,931; *Regulator*, J. Graves, 127,972; *Electrolysis Apparatus*, W. E. Tilley, 128,081; *Therapeutic Bath*, J. R. Anderson, 128,094; *Printing Telegraph*, T. A. Edison, 128,131; *Electrolysis Apparatus*, D. D. Parmelee, 128,166; *Gas Lighter*, H. C. Appleby, 128,201; *Automatic Telegraphs*, G. Little, 128,405; *Circuit Closer*, J. Rowe, 128,427.

[Drawings and specifications of any patent will be furnished by Mr. Brock at cost, 15 cents each.]

THE

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VOL. VIII. NEW YORK, JULY, 1889. No. 91.

THE ELECTRICAL EXECUTION LAW.

AS the appointed time for the execution of the murderer Kemmler at Auburn prison approaches there are evidences of a growing public suspicion that the act of the New York legislature ordaining the employment of electricity for the execution of criminals convicted of capital crimes was a piece of hasty and ill-advised legislation. The act received, at the time of its passage last year, a good deal of thoughtless commendation from well meaning and benevolent people, under the belief, no doubt, that death by electricity must be instantaneous and painless, and that the application of it was the simplest thing in the world; in short, that the commission appointed by the laws of 1886 and 1887, "to investigate and report at an early date the most humane and practical method known to modern science of carrying into effect the sentence of death in capital cases," had been unquestionably successful in their research when they reported and recommended the employment of electricity." That the commission did not select, and the state adopt, the "most practical" method is made apparent to everybody by the published accounts of the elaborate machinery and apparatus provided and to be set up in the state prisons to supplant the simple and practical, though perhaps not humane, halter and gallows; while the requisite preliminary manipulation and harnessing of the condemned before the current be applied, involving a considerable period of expectant attention on the part of the victim, make it clear that the labors of Mr. Elbridge Gerry's commission, the state legislature and the Medico-Legal Society—and we must not omit Mr. Harold P. Brown, who has devoted his talents and electrical engineering acquirements to the subject from the beginning—have not secured the adoption of the "most humane" method of inflicting the death penalty; even if it could be proved that death would be instantaneous upon the application of the current.

But it is far from being proved that death by the electric current is quicker or less agonizing than death by many other agencies; nor is it even certain that the electric current will invariably kill without mutilation or disfigurement of the body.

We have before us the report of the commission above referred to, made to the legislature of New York, January 17, 1888, the committee consisting of Elbridge T. Gerry, Alfred P. Southwick and Matthew Hale. Their report, recommending the action subsequently taken by the legislature, is a document of 100 pages, and must be regarded as a grotesque performance, in view of the precise and limited subject assigned to the commission for investigation and recommendation. The Commissioners gratuitously burdened themselves—and their readers—by giving a history of criminal law from the earliest times, reciting all the capital offences in the Mosaic code, with book, chapter and verse, and bringing the history down to the present period through some 50 pages, describing minutely by the way all the barbarous and horrible modes of execution known, and following this ghastly record with 30 pages of detailed accounts of particular executions by various methods, and all this with a minuteness and unction more consistent with a morbid and unnatural, than with a sane and rational interest in the subject before them. No one will question the philanthropic intentions of the commissioners in making their report, but it would seem that to avoid the horrors attending executions in the past, and too often at present, and to recommend *something* as a substitute for the gallows at once, they were betrayed into committing themselves to the adoption of an agency that they knew little or nothing about, and concerning the efficacy of which, in the direction of more practical and humane executions, there is much and grave doubt on the part of those best acquainted with electricity.

THE ELECTRICAL ENGINEER does not share the feeling expressed by some electricians that the employment of the electric current in capital punishment would disgrace or stigmatize their vocation; we take the liberty, however, to point out the following paragraph from the report of the commission:—

> Your commissioners are firmly convinced that if the criminal could be put to death in a certain and efficacious manner, the purpose of the law would be achieved equally well as if the terrors of death were enhanced by the infliction of prolonged physical torture before the end was finally accomplished.
>
> Various suggestions have been made as to the means of accomplishing such a result. One has been the injection of a violent and sudden poison, such as prussic acid, by means of the hypodermic needle, into the body of the condemned, which is open to the very serious objection that the use of that instrument is so associated with the practice of medicine, and as a legitimate means of alleviating human suffering, that it is hardly deemed advisable to urge its application for the purpose of legal executions against the *almost unanimous protest of the medical profession.*

We are not told when and how the medical profession was polled on the question, but the above paragraph clearly implies that the suggestion of poison was satisfactory but for the feelings of the doctors.

It has always seemed to us, that the question of simpler and more humane executions could be best met by physicians. There is no doubt that they could provide a

simple method of poisoning, which could be applied with no expectant attention on the part of the condemned—unawares, say in sleep, if desirable, as we think it is—and which would be nearer certain to inflict no conscious physical suffering than any other means hitherto suggested.

COPPER.

SINCE our last issue there has been a material advance in the price of copper in Europe, and while the rate here has remained substantially unchanged, the price of copper mine shares is stiff in Boston. Apparently no considerable portion of the enormous surplus of copper left on the hands of bankers in Paris by the collapse of the syndicate has been put upon the market. Notwithstanding the reported failure of the representatives of American copper mines who went to Paris to effect an arrangement with the Paris holders of the accumulated 175,000 tons, and with the foreign mining companies, for keeping up the price, there are very strong indications that a far reaching combination has since been effected. The agreement sought to be made at Paris is reported to have been as follows:—that the price of copper should be fixed and maintained—that the price in Europe should be about £45—that the American and foreign mines should restrict their output, and that the accumulated stock of the broken syndicate should be doled upon the market at the rate of 20 per cent. a year.

The *New York Times* of June 23, says, "It has been stated upon the authority of a producer who attended the conference in this city [after the return of the American representatives from Paris], that an international agreement was made with the new provisions that the Paris bankers should not attempt for four years to sell in this country the 50,000 tons of the syndicate's stock remaining on this side of the Atlantic, that the exports of American copper should be reduced in some measure, and that the price of good merchantable in Europe should range between £40 and £45 per ton. There were published on the 24th ult., despatches from Paris saying that all the American mines except the Tamarack had 'ratified the provisional arrangements concluded with M. Mozeau, the liquidator of the Comptoir d'Escompte.' These arrangements relate to the old syndicate contracts, but they may include or depend upon some provision for controlling the market, and it was reported in the London *Economist* on the 25th ult., that they did provide for a restriction of output."

The lake companies, however, up to June of the current year produced more ore than during the first six months of 1888, and there is some reason to doubt whether they have agreed to diminish their output. But that an agreement or combine with the Paris bankers to hold up the price has been effected seems beyond doubt.

In an editorial article entitled "Copper Rings and Duties," the *New York Tribune* of May 15, sounded the following note of warning:—

> The copper tariff now depends upon the conduct of those who control American mines. It is quite possible for them to insure a removal of the duty on copper, if they enter into a new compact for the benefit of French bankers who have lost millions in attempting to fleece the public. The mine owners have publicly stated that they are able to produce more than all the copper this country consumes, and a large part of it at a cost not exceeding six cents per pound, and that they proposed to the French bankers, who hold an enormous unsold stock, to fix the selling price at about 13 cents per pound—more than double the cost. Nothing need be said about the right of the producer to get a profit of more than 100 per cent. on his copper, provided he is not a beneficiary of a national policy intended to protect and encourage American production. But the mine owners are beneficiaries of that policy, and owe to the public a certain consideration and service in return. If they enter into a combination for the benefit of foreign speculators and bankers against the interests of American producers, the duty on copper may not last long.
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> * * * * * * * *
>
> There will in all probability be a revision of the tariff next winter. The party in power, being anxious to defend all industries that need and merit defense, will for that very reason be more strongly pressed to cut off duties where no defense appears to be needed, or where it seems to be not deserved. Combinations of speculators to corner the markets of the world are not highly popular, and will not appear to members of Congress to merit particularly favorable consideration. Under such circumstances, the demand for a removal of all duties on copper ore, pig and bars, will be difficult to resist. It is safe to say that, had the Mills bill proposed no change more unpopular or unobjectionable than that, its public support would have been incomparably greater. In the light of these facts the copper producers may wisely think twice, and more than twice, before they enter into any new bargain to control the markets and extort money from consumers.

There needs no addition to the above words of the leading protectionist journal of the country upon the merits of the duty on copper, a feature of the existing tariff which deeply affects the interests of electrical industries.

A SUPPLEMENT TO THE BATE DECISION.

IN an editorial article published in the March number of THE ELECTRICAL ENGINEER, commenting upon the decision of the Supreme Court in the Bate case, we expressed an opinion to the effect that the reasoning of the Court, if followed out to its legitimate conclusion, justified the deduction that the premature termination of a foreign patent—as, for instance, by the failure of the patentee to pay taxes or stamp duties—would render void a previously issued United States patent for the same invention.

The soundness of our position was seriously questioned by an esteemed correspondent, whose letter we printed on page 182 of our April number. But we are now assured, on the authority of Justice Thayer, of the United States Circuit Court, of Missouri, that we were right. In a carefully considered opinion in a recent case, involving the very point (of which we give an abstract in another column), referring to the Supreme Court decision in the Bate case, the learned justice says:—

> The arguments used in the course of that decision lead logically to the conclusion that United States letters patent, issued subject to the provisions of section 4,887, remain in force no longer than the foreign patent having the shortest term; *that the life of the domestic patent is measured by the actual duration of the foreign patent, and may be abridged as well as lengthened by circumstances operating under the foreign law to abridge or lengthen the foreign monopoly.*

At the time the Bate decision was announced, it will be remembered, we expressed the opinion in substance that it might prove an unpleasant surprise for the owners of a good many valuable patents, the validity of which had never been seriously questioned. Without reiterating the emphatic opinion we have already expressed in respect to the ridiculous statute upon which these decisions are based, we cannot refrain from gratification that the legal acumen of an able judge has led him to the same interpretation of the Bate decision that we ventured to express in these columns.

OUR Chicago correspondent makes mention of the handsome offer of $600,000 by Mr. Rockefeller toward the establishment and endowment of a University at Chicago, provided that the Baptists of the west shall raise $400,000 to make the sum $1,000,000. It is proposed to include scientific and technical work of a high order in the contemplated university, with a probability of a course in electrical engineering. It seems ungracious to assume a critical attitude towards any munificence like that of Mr. Rockefeller; but we cannot forbear asking, "Why the Baptists of the west?" Why not the Presbyterians, Methodists, Catholics, even the Unitarians and Hebrews, of the west or any other region? Why, in advance, narrow the foundation or the lines of so large a project for an institution of learning, by giving it a denominational, character? Excepting theological seminaries, the establishment of any more denominational institutions of learning, academic or scientific, would seem to be a misfortune to the cause of higher education, and the larger the endowment and the institution the greater is the misfortune. The essential work of a university seems to be neither Roman Catholic, Unitarian, Methodist nor Baptist; not even Christian, Jewish or Mohammedan, as such, being simply the provision of facilities for instruction and research in the literature, science and art of the world. Our leading colleges have lost much of the sectarian character given them at their foundation, and are fast getting rid of the remainder, whilst several of the larger and more important of comparatively recent foundation, have never had any denominational character either by name or implication.

IT is gratifying to note that substantial progress has been made in constituting and organizing the National Committee on State and Municipal Legislation, in accordance with the action taken by the Electric Light Association in February last. The energetic chairman of the committee, Mr. A. R. Foote, of Cincinnati, reports that nineteen nominees have accepted appointments to represent their several states on the committee, of whom eight have joined the Electric Light Association. In view of the tendency so often exhibited by state and municipal legislative bodies to pass hasty and ill-digested enactments touching electrical industries, there can be no question of the great usefulness of the work that can be accomplished by the committee when fully organized. In a recent circular Mr. Foote points out, with much force, that the duties of any member appointed to the committee will be lightened rather than increased by his acceptance. He will have little, if any, call upon his attention during the inaction of the legislature of his state or city upon electrical matters; and when hostile or injudicious legislation is on foot he will have the assistance of the members of the committee, derived from their experience in other states, with prompt access to facts and records which it would be difficult to get at single handed. Unjust or oppressive regulation and restriction of electrical industry is more frequently due to ignorance or misinformation on the part of legislators than to discreditable motives, and the National Committee can be made a powerful agency for the dissemination of facts and forcing them upon the attention of legislative bodies.

THE application of electric propulsion to the transportation of the mails and of light parcels over long distances is receiving the attention of inventors and promoters in several quarters. The problem is somewhat more difficult and complicated than that of electric railroads. The special difficulties would seem to lie, in great part, in the distribution of the requisite power over very great distances, and in the necessity of despatching the carriages to make their long journeys without the presence of an attendant. Nevertheless, the obstacles are boldly attacked, and two companies seem to be preparing for business, viz.:—The Electro-Automatic Transit Co., of Baltimore, based upon the Weems' system, and the New England Portelectric Co. of Boston, the latter exploiting the inventions of Mr. John T. Williams. This company, whose felicitous title deserves a word of commendation, proposes to establish a practical line in the vicinity of Boston at an early day, and in the meantime is generously offering an opportunity to country ministers, teachers and others having a little spare cash, to participate in the profits of the enterprise by investing in its shares, the par value of which has been placed at the conveniently small sum of two dollars.

WE have very great pleasure in printing elsewhere in this issue (though received too late for proper classification), Mr. Grosvenor P. Lowrey's letter, touching our editorial remarks last month upon the passage in his argument in the Westinghouse-Edison suit referring to the expert testimony of Mr. F. L. Pope. We do not believe that Mr. Lowrey ever deliberately misrepresented anybody, and can, in the light of his explanation and *amende honorable*, readily understand how he was led into his former erroneous statement.

ON Tuesday evening, June 25, the American Institute of Electrical Engineers held its last monthly meeting of the present season, in the lecture-room of Professor Doremus, at the College of the City of New York. Mr. Leo Daft read a very interesting and suggestive paper on Some Recent Electrical Work on the Elevated Roads and its Bearing on the Rapid Transit Problem. The hearing and discussion of this paper closed fitly a successful year of the Institute's work, which will be resumed in the early autumn with renewed and augmented interest.

POINTERS.

.... IT would be quite impossible to forecast the future, even for a single decade, with reference to the applications of electricity, even though discovery were ended. The mere expansion of industries already in some degree established will give them an importance which we cannot now estimate. But discovery is not ended, and it is more than probable that results will yet be reached which, although they cannot be at variance with the general doctrine of energy as now understood, may, to some extent, revolutionize our methods, with corresponding advantages.—*Professor C. F. Brackett*, in June *Scribner's*.

.... MR. KING said that a secondary battery ought to be used in the same manner as a gas company used a gasometer, as a reservoir, and as a means by which a constant small additional supply of electricity might be available during the hours of maximum pressure.—*Electrical Review*, London.

... LOOMING in the distance, but coming nearer and nearer year by year, is an important rival to gas, which science teaches must eventually supersede all other means of conveying energy, whether for lighting or for power, viz., electricity.—*Major Gen. Webber, R. E.*

ARTICLES.

WHERE SHALL WE PLACE THE ENGINEER?

BY GEORGE H. STOCKBRIDGE.

The relative importance of the liberal and the useful or practical arts is an old subject of discussion, to which Sir Frederick Bramwell, as president of the British Association for the Advancement of Science, recurs, in his opening address at the last session. Classical antiquity, under the lead of the Greeks, took strong ground in favor of the liberal arts, relegating so-called useful knowledge to second place. The Romans, to be sure, builded better than they taught, and it might be a question whether they contributed more to the civilization of the world by their theories or by their practice—by the disquisitions of Cicero, or by their magnificent roads and sewers. It would not be so very wide of the mark to say that the theories were embodied in the civilization of the Dark Ages, and the practice in our own. At all events, it is certain that the civilization of the Western world has never been at so low an ebb as during the time when it was dominated by those who held the keys of "liberal" learning in the schools and monasteries of Europe. It was reserved for Bacon to give something like their proper position to the bridges, roads, and aqueducts of the world as compared with its statues, its poems and its paintings. The lines have shifted a good deal; but, in general, even in a time pre-eminent for inventions, we stand with the Greeks. The imagination at play is exalted above the imagination at work, and preference is given to artistic and literary over utilitarian studies. It is still a general feeling that the scientific course at college is partial or subordinate, less creditable as a choice, and less cultivating than the so-called classical course. We do not take the trouble to question Mr. Matthew Arnold very seriously, when he insists that conduct, "which is three-fourths of life," is shaped more by literature than by science, and that, therefore, literature is pre-eminent.

Professor Rowland would probably not agree with Mr. Arnold without some argument. He urges, very properly, that no training to which a young man can be subjected is equal to a scientific education for inculcating thorough honesty. When a man knows that correct deductions from his experiments depend upon the absolute accuracy of his description of them; that science would be impossible without confidence in the perfect reliability of its chroniclers; he learns, of necessity, a valuable moral lesson.

The men of letters have had matters pretty much their own way. Most men take their opinions from what they read, and, with the writers the natural tendency to magnify their office has found expression in just that form which would be most likely to impress the imagination. The skillful portrayal of a character receives more attention from the literary critics than the character itself, and in the end we give the credit to the artist. Fortunate Achilles, no doubt, to have had Homer for his panegyrist, unless, indeed, the panegyrics since bestowed on the poet have obscured the fame of the hero. Sallust gravely argued that it is more difficult to write the history of great deeds than to do them, and authors generally have not been over modest about their importance in the world. The result of all this has been that the literary life, and, incidentally, all art life, have been glorified at the expense of the life devoted to practical or utilitarian ends.

This tendency has been most marked among those who employ a narrow definition of literature, making it the vehicle for the expression of the beautiful in language; though Mr. Arnold has developed it on other grounds, as we have seen. The beautiful, they say, is the highest end of human endeavor, and these railroads and telegraphs destroy beauty. Therefore, away with them, for Goths and Vandals. So say Mr. Ruskin and his school. So say those who reckon Keats above Shakespeare. Goethe, with his sane views of life, was, perhaps, the first poet of eminence who took the side of the engineers. The culmination of the Faust drama is the draining and fertilizing of a waste region and making it habitable for a needy people. By the accomplishment of this engineering work the redemption of Faust is completed. Wordsworth followed Goethe, and, as might have been expected, our two most representative poets, Lowell and Emerson, have come to their support. These claim justly that the railroad, the canal and the steamboat add interest to natural scenery by reminding the spectator of the progress of man.

Following the natural tendency of such matters, the quarrel, which began in the Greek mind as a contest between the useful and the beautiful, becomes belittled with many to a dispute between the useful and the useless. "Here's to the latest discovery of science; may it never be of service to anybody." This zealous toast expresses a common sentiment among our cultivated people. To make a new discovery useful is in their judgment to degrade it, to render it vile and common. Let it be kept for the few who will fitly appreciate the subtle processes by which it was reached and will preserve it from utilitarian desecration. Happily, this sort of thing is less in vogue than it was, and there are already signs enough to show that the time is coming when all art and literature will themselves be closely catechised and justified only when they serve a useful end.

The question called up by Sir Frederick Bramwell, however, lies between pure science and scientific engineering. In the ultimate refinement of these matters, we have got so far that the scientists, or laboratory investigators, claim precedence over those who apply scientific facts to the amelioration of the condition of the race. Sir Frederick easily shows that the full development of a science is impossible without the engineer; that the higher qualities of imagination and invention are called into exercise in engineering; and that such work is entirely worthy of the loftiest mind. It might be added that the most considerable factors in modern civilization have been the printing press and the telegraph; that the world has never made such rapid strides towards "humanization" as since the spirit of invention has been fostered and encouraged. It is a singular fact, and one that shows how little, after all, our artificial culture has done for us, that if you restore the external conditions of barbarism, barbarism in truth soon reassumes possession of us. It does not take long for the descendants of New England Puritans, transferred to the western frontier, to retrograde into savagery in manners and customs. Quick communication, such as is furnished by the railroad and the telegraph, making "neighbors of the antipodes," and keeping up the moral nearness of distant friends, probably does as much to restrain crime and degradation in sparsely settled districts as any other influence. In other words, improvements in material affairs play necessarily, a most important part in the civilization of mankind. Not only that, but they represent, in themselves, a culture quite as refined as the artistic productions of a people. If we can suppose that some cataclysm should engulf the American people to-day, it is probable that future explorers, coming upon the traces of our existence, would form quite as high an opinion of our civilization from a Corliss engine as from the works of Walt Whitman.

It is significant that the engineer at present is finding a good many eulogists. Sir Frederick Bramwell has done his part. The Scribners are doing theirs by publishing an extended series of articles on railroads and electricity—exceedingly well written articles, too—showing that some of the literary classes are interested, or that some of the engineers excel in two arts. It is true the railroads had acquired an enormous growth and importance before this honor was accorded them, and that the electrical arts should be similarly honored, tells its own story.

After all, it is, as has been intimated, only the pseudo-literary and the pseudo-scientific workers that belittle the occupation of the engineer, and it is only to them that the claim of a higher vocation is here denied. The true artist's position is one of appreciation for all that makes for righteousness and for all human progress. Strangely enough, Leigh Hunt, of all men, has stated the truth on this point, and it is good enough to be the final word at this time. He says: "As treatises on poetry may chance to have auditors who think themselves called upon to vindicate the superiority of what is called useful knowledge, it may be as well to add that if the poet may be allowed to pique himself on any one thing more than another, compared with those who undervalue him, it is on that power of undervaluing nobody, and no attainments different from his own, which is given him by the very faculty of imagination they despise. * * * * * No man recognizes the worth of utility more than the poet; he only desires that the meaning of the term may not come short of its greatness, and exclude the noblest necessities of his fellow creatures. He is quite as much pleased, for instance, with the facilities for rapid conveyance afforded him by the railroad, as the dullest confiner of its advantages to that single idea. But he sees also the beauty of the country through which he passes, of the towns, of the heavens, of the steam engine itself, thundering along like a magic horse; of the affections that are carrying, perhaps, half the passengers on their journey; and, beyond all this, discerns the incalculable amount of good, and knowledge, and refinement, and mutual consideration, which this wonderful invention is fitted to circulate over the globe, perhaps, to the displacement of war itself, and certainly to the diffusion of millions of enjoyments."

THE PERSONAL ERROR IN PHOTOMETRY.[1]

BY PROFESSOR EDWARD L. NICHOLS.

WHENEVER, in the course of photometric work, different observers have occasion to compare the same pair of lamps, it will be found that the result of their readings with the Bunsen photometer differ by an amount very much larger than the apparent mean error of a single observation.

Ordinarily, these differences are cloaked by the accidental errors due to the fluctuations of the lights under observation, and they have, consequently, not received the attention which they merit. There has been, indeed, so far as I know, no systematic attempt to determine the precise nature and importance of this personal error, the existence of which has doubtless been recognized by very many observers.

The introduction of the storage battery and the adoption of the incandescent lamp, supplied from the constant source thus afforded, as a secondary standard, has, however, entirely removed the large accidental errors resulting from uncontrollable fluctuations in our standard of illumination, and the personal errors just alluded to accordingly stand out in their true importance. I have very recently had occasion to make some experiments upon this subject, the results of which may be of some interest to those who have occasion to work with the Bunsen photometer.

The character of the errors with which one meets continually, whenever the reading of two or more observers are brought into direct comparison, may be very well shown by means of two sets of readings made by Mr. B. W. Snow and myself upon the same pair of lamps. These observations were made under precisely similar and uncommonly favorable conditions. The two lamps in question were of the same type, and being the only lamps in circuit with a large storage battery, they could be maintained at an almost absolutely constant voltage. These two sets of readings are not presented here as an example of what may be done with the Bunsen photometer in the comparison of constant sources of light. They are indeed of no great accuracy, and contain larger accidental errors than some observations to which I shall have occasion to call attention presently. They exhibit, however, very clearly the existence of the personal errors of observation which are to form the subject of this paper.

TABLE I.

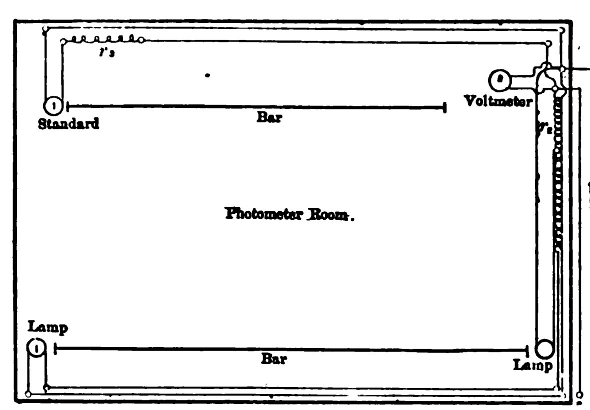
Two parallel sets of 10 readings upon the candle-power of an incandescent lamp.

(1) (B. W. S. observing.) Readings.	Differences.		(2) (E. L. N. observing.) Readings.	Differences.	
C. P.	C. P.	P. C.	C. P.	C. P.	P. C.
12.12	.112 —	.91	12.56	.044 —	.35
12.32	.088 —	.72	12.60	.084 —	.67
12.16	.072 —	.59	12.36	.156 —	1.25
12.16	.072 —	.59	12.56	.044 —	.35
12.28	.048 —	.39	12.64	.124 —	.99
12.40	.168 —	1.38	12.60	.048 —	.67
12.28	.048 —	.39	12.56	.044 —	.35
12.08	.152 —	1.30	12.40	.116 —	.93
12.12	.112 —	.92	12.32	.196 —	1.35
12.40	.168 —	1.24	12.56	.044 —	.35
AVERAGES.					
12.232	.104	.852	12.516	.089	.717

It will be seen from the above table that while the apparent mean error of a single observation is only about one-tenth of a candle, and the probable error of each set only .022 candle, the two averages themselves differ by .284 candle.

The following experiments were made for the purpose of determining the nature of this personal error:—

Three incandescent lamps of the same type and voltage were selected, care being taken to choose specimens the carbons of which were as straight as possible. These lamps gave 16 candles at 110 volts. They were connected in multiple to the terminals of a storage battery giving a potential difference of 120 volts. Adjustable resistances of german-silver wire were placed in the line leading to each lamp and in one of the mains leading from the battery. (See figure.)



The lamps, together with the above-mentioned resistances, were set up in a photometer room which contained two Bunsen photometers. The connecting wires were of such length that the lamps could be moved from one photometer bar to the other without breaking connections. One of the lamps was set up as a comparison standard at the end of the shorter bar. Each of the other lamps was then compared with this standard, the resistances being adjusted until these lamps were found to bear the same relation as to brightness to the standard. In other words they were brought to the same intensity by a method which eliminated the systematic personal errors which it was my purpose to study.

The two lamps were then placed at the ends of the longer photometer bar, the length of which was 400 centimeters. It was divided into 800 equal parts. The lamps

1. A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

had been measured with the plane of the filament at right angles with the photometer bar, and care was taken in setting them up in their new position, to place them at the same angle and presenting the same face to the bar as before.

A closed circuit voltmeter between the terminals of the battery enabled the observer at the beginning of a set of readings to bring the lamps to the proper potential. In order to insure greater constancy in the degree of incandescence throughout the series of tests, the lamps were maintained at a potential considerably below the normal, their candle-power being about 12 instead of 16 candles.

A number of observers, all of whom were accustomed to photometric measurements and some of whom had had extended experience, were asked to make a set of 10 readings each, upon the two lamps. The results of these two readings are given in table ii.

TABLE II.

Ratio of two incandescent lamps, previously adjusted to equal brightness. The measurements are made in the usual manner, by means of the Bunsen photometer.

I_r and I_l are the intensities of the right-hand and left-hand lamps respectively.

Observer.	Ratio $-\frac{I_r}{I_l}$	Personal error.
A	1.0590 ± .0040	— .0558
B	0.9701 ± .0044	+ .0331
C	1.0021 ± .0022	— .0189
D	1.0191 ± .0072	— .0159
E	1.0182 ± .0039	— .0150
F	1.0902 ± .0057	— .0870
G	1.0733 ± .0053	— .0701
H	1.0293 ± .0042	— .0261
I	1.0297 ± .0050	— .0263
J	1.0220 ± .0027	— .0188

The true value of the ratio, $\frac{I_r}{I_l}$, determined previously by comparing each lamp separately with the standard, was 1.0032 ± .0015, which value was used in computing the "personal" error.

It will be seen from inspection of the table that none of the averages fall at the middle of the bar, nor are they distributed around it in such a manner that the most probable value of the entire series, calculated by least squares under the assumption that only fortuitous errors exist, approximates to unity as it should do, were the lamps of equal brightness and were there no systematic errors to vitiate the result. On the other hand the readings lie, with a single exception, on one side, namely to the left-hand of the centre of the photometer bar. It will be seen, moreover, that the probable error calculated for each set separately, without taking cognizance of any systematic error, is very small in comparison with the differences between the mean results of the various sets, and especially in comparison with the variations of those averages from unity.

The Bunsen disc with which these observations were made, was mounted in the usual manner, the two sides of the disc being viewed simultaneously by means of two plane mirrors set at the proper angle behind the former. It was noted that the almost universal habit in reading was to use the two eyes independently, one eye fixed upon each side of the disc. It seemed probable, therefore, that the personal error arose from the unequal sensitiveness of the observers's eyes, in that he would unconsciously set the disc at too great a distance from the lamp which illuminated the side of the disc which was being observed by his more sensitive eye. It appears, if we accept this explanation, that the right eye was the more sensitive in all the cases under observation excepting one, that of the writer (see table ii. B), whose readings would indicate the opposite peculiarity.

In order to reverse the relation of the observer to the photometer bar, without altering any of the other conditions of measurement, a large mirror was set up opposite the photometer at a distance of about 40 centimeters. The observer, by sitting with his back to the bar, could then see the images of the Bunsen disc in the mirror, and his right and left eyes were reversed with reference to the lamps. Sets of 10 readings were made in this manner by some of the same observers as before, the object being to test the hypothesis just stated. The results thus obtained were, however, complicated by the unforeseen circumstance that the method of using the eyes in observation was not the same when the image of the disc was seen in the mirror as when it was viewed directly. The observer, when using the mirror, no longer used his eyes independently, but scanned the image as a whole, so that both eyes had a share in determining the brightness of each side of the disc. The result was to produce a change in his settings, not by introducing a systematic error, equal and opposite to that occurring in the first series of observations, as had been expected, but by eliminating the error in question. In a word, the settings with the mirror were in better agreement than those made by direct observation, and they gave results much more nearly in accordance with the known equality of the lamps.

In my own case, however, an exception to the above statement must be noted, very possibly as the result of an effort to repeat with the mirror the precise method of observation followed in making the direct settings. I continued to use my eyes independently, viewing the image of one side of the disc with the right eye, the other with the left. There resulted a set of readings, such as I had expected to obtain from all the observers, the mean of which lay as far from the centre of the photometer bar as the mean of the direct readings, but upon the other side. (Compare sets "B," tables ii. and iii.)

The results obtained with the mirror are given in the following table :—

TABLE III.

Ratio of the two lamps, determined by observing the images of the Bunsen disc in a large mirror ; the observer placed with his back to the photometer bar :—

Observer.	Ratio.. $\frac{I_r}{I_l}$	Personal error.
A	1.0070 ± .0026	.0028
B	1.0444 ± .0011	.0414
C	0.9964 ± .0053	.0068
F	1.0141 ± .0025	.0109
G	1.0004 ± .0056	.0028
H	1.0134 ± .0045	.0102
I	1.0004 ± .0031	.0028

The observations with the mirror were followed by four sets of direct readings made with one eye bandaged. It was found that although more fatiguing, these monocular settings were made with a feeling of certainty on the part of the observer which had not accompanied the settings made with both eyes. In the latter case, indeed, a conflict between tendencies to set the disc in two distinct positions had been very apparent, the observer unconsciously choosing now one, now the other, as the true positions. The set of readings given in full in table iv., will serve to illustrate the result of this tendency. The instances in which the observer seems thus to have temporarily changed in his judgment of the true setting, are printed in heavy type.

TABLE IV.

No.	Reading.	No.	Reading.
1	1.033	6	**1.048**
2	1.022	7	**1.053**
3	1.021	8	1.023
4	1.023	9	1.033
5	**1.050**	10	1.030

This tendency to vacillation disappeared almost entirely when only one eye was used. The readings obtained with a single eye not only agreed much better among themselves than those made under like conditions using both eyes, but the results obtained with the left eye were identical with

those obtained with the right eye, and both seemed to be entirely free from the systematic personal error that had been found to vitiate readings made in the usual way.

The results of such a set of monocular readings, made by Mr. Snow and myself, all other conditions remaining the same as in previous trials, are given in table v.

It will be seen that the probable error of each set is much smaller than in the sets of observations made with both eyes; also that the readings of two observers whose mean results from similar sets with both eyes had differed by eight per cent. (see sets "A" and "B," table ii.), are in complete agreement.

Finally, it will be noted that the results of these four monocular series differ from the accepted value of the ratio of intensities of the two lamps (1.0032) by an amount less than the probable error of each set.

TABLE V.

Observer.	Eye used.	Ratio.	Personal error.
B. W. S.	(Right.)	$1.0028 \pm .0019$	.0004
B. W. S.	(Left.)	$1.0001 \pm .0019$	.0031
E. L. N.	(Right.)	$1.0001 \pm .0017$	.0031
E. L. N.	(Left.)	$1.0031 \pm .0018$	.0001

It had been my intention to extend the experiments described in this paper to a much larger number of observers.

The evidence obtained, however, seemed quite sufficient to establish the existence of the personal error in photometry, and to show that it was in general very far from being a negligible quantity. Frequent repetitions showed, that in my own case at least, the error was very nearly constant, and I think that it would be quite possible to establish a personal equation, and to apply the proper correction.

A much better plan, however, would be to so modify the photometer car itself as to insure the use of both eyes in the inspection of each side of the illuminated disc. Several forms of photometer, already described, partially fulfill the necessary requirement. Any device which would bring the images of the opposite faces of the disc into a vertical line in the field of view would doubtless serve to eliminate the error in question. Observations with such a photometer would correspond in character to the "monocular" readings given in table v. Not only would they be free from the systematic error to which the ordinary form of Bunsen photometer is subject, but the accidental errors would be much smaller, and the degree of uncertainty which attends the determination of candle-power by our present methods would be in great measure diminished.

Physical Laboratory of Cornell University, May 17, 1889.

SOME RESULTS WITH SECONDARY BATTERIES IN TRAIN LIGHTING.[1]

BY ALEXANDER S. BROWN.

THE arguments in favor of the incandescent electric light for railway passenger trains, are so well understood by the members of the Institute, from their own general knowledge of the subject, as well as from papers previously presented, that it is unnecessary for me to allude to its admitted superiority over either gas, oil or candles. It is now four years since the Pennsylvania railroad, appreciating the advantages of electric lighting for this purpose, began a series of experiments with the secondary battery, for the illumination of parlor cars.

I am unable to give the cost of lighting by any of the batteries referred to, as the expense appears to have been a secondary consideration compared with the necessity of securing the best system of illumination.

The first experiments made by the company were with the Faure accumulator which was brought to this country from France in the spring or early summer of 1882, and put on passenger coach No. 397 in August of that year. The car was run for a few days only, but enough was learned in that time, to show that the lighting of cars by secondary batteries was perfectly practicable, when a modified form of the battery could be obtained.

During the summer of 1884, experiments with the Brush storage batteries were commenced at the Altoona shops of the Pennsylvania railroad, and continued through the fall and winter of that year. These experiments were made by Dr. Dudley, and proved so successful that eight parlor cars, which were being constructed at that time, were equipped for incandescent lighting and put into regular service on the 1st of April, 1885.

The Brush cells used consisted of three plates each, two negative and one positive, the amount of surface of the positive plate being equal to that of both the negatives. These plates differed from those now used, there being no paste in their composition. The negative plate herewith shows the form of construction, and was designed to give the greatest possible amount of surface from the least weight of material. The positive plate measured 8″ x 9″ x 1″ and the negative 8″ x 9″ x ½″.

These batteries were rated at 70 ampere hours, but the hard usage they received soon reduced their capacity, and at the end of a year's time the positive plates were almost entirely destroyed. In fact I have taken plates out of the cells which had holes in them fully four inches in diameter, while the deposit in the bottom of the cell would be from an inch to an inch and a half in depth. The plates also had a decided tendency both to buckle and grow, and in a number of cases it was a very difficult matter to remove the plates without injury to the cell; you will understand, of course, that I allude more particularly to the positive plate. The weak points in the Brush battery were the small number of ampere hours per pound of material—about two I believe. There was a tendency to buckle and sulphate, and the arrangement for connecting the plates was such that there was oxidation at the junction, causing the plates to break when subject to the motion of the car. This last feature was a source of endless trouble to us, and as is usually the case, was sure to happen at a time or place where it was impossible to repair the break. While using the Brush battery the cars were wired with the battery boxes, one on each side of the car, coupled together in series, each box holding three trays, and each tray containing four cells, this giving a total of 24 cells to a car, or a current of 48 volts. The lamps used originally were of the Brush-Swan type, with small platinum hoops projecting from the base, these hooking into a socket, and held in place by a spiral spring, this socket fitting into another one, to which the connections to the wires were made.

After using this style for some time, an improved pattern of Brush-Swan lamp was substituted, but the great drawback to this lamp was its frailty, the breakage per day often averaging four per cent. of the total number of lamps in use on all the cars. These lamps required about 45 volts and one ampere of current, and each car contained 10 lamps, seven in the body, one in the smoking room and one in each vestibule, thus using about 10 amperes of current, and as the batteries were rated at 70 ampere hours, we should have obtained from six and one-half to seven hours good light, but it was very seldom, after the batteries had been used for a short time, that we could get over five and one-half hours. As will readily be seen this could hardly be called economical, for to obtain five or six hours' light we were obliged to charge from 15 to 20 hours with a Brush arc light dynamo giving a current of about 10 amperes. Then taking the weight into consideration, each time the car needed charging, the trays, six in number, and weighing 1,200 pounds, had to be loaded on the truck, pulled over to one side of the car, and there discharged trays taken out and the freshly charged ones put in their place. The remaining three were then taken around to the other side

1. Read before The American Institute of Electrical Engineers, New York, May 22, 1889.

of the car and changed in the same manner. As the cars invariably stood on a double track it was necessary to carry half the trays for some distance, over tracks, etc. Then, again, the tracks were usually full of cars, and if there was not sufficient time for them to be parted the batteries had either to be carried under the car or over the platform. Under the present system this has been done away with to a great extent, as will be explained subsequently. During the month of December, 1886, we commenced using one battery of the 7 B type, manufactured by the Electrical Accumulator Co. This battery was a decided improvement over those previously used, giving as it did nearly double the number of ampere hours for the same weight of material. After using this battery for about a year the positive plates began to give way and new ones were substituted, the negatives however being retained, they not having deteriorated. In fact we are still using the negative plates of our original 7 B battery. This battery proved to be so satisfactory that in June, 1887, we added two more of the same type, and two manufactured by the Julien Electric Company. The latter batteries were similar in size and shape to the 7 B type of the Accumulator company, but did not seem to stand the hard usage so well, as they would crack instead of buckling and allow a large quantity of the paste to become loosened and fall out. It is proper to state, however, that these plates were made especially for us, to fit the cells we were using, and were not of the regular Julien type. This no doubt will account in a great measure for their failure to keep up to the standard of the present type of Julien batteries. After the positive plates of this battery became worthless, and not having any others to put in their place, we decided to make a kind of consolidated affair and see how Julien negative and Accumulator positive plates, would work together. The result was extremely satisfactory, and we have had no trouble with them whatever, excepting the occasional buckling of a positive plate.

During the fall of 1887, we began substituting the Accumulator batteries for the Brush batteries, and by the end of the year we were using them altogether, with the exception of the two Julien, I have mentioned. We however kept 96 of our best Brush cells, to be used in case of an accident to the incandescent dynamos, which are used to supply the current for the railroad telegraph as well as for lighting the passenger station.

After the change in batteries had been made, it was thought best to change the system of wiring the cars, so that instead of its being necessary to put batteries on each side of the car, we need only put them on one side and get the same amount of light. This was done by connecting the two boxes under the car in parallel, and substituting 23 volt Edison lamps for our 45 volt Brush-Swan lamps. After doing this we found that we were able to get as many hours light from 12 cells as we formerly did from 24. Of course this change reduced the expense of lighting the cars considerably, for where we formerly had a change of battery for each car, or 48 cells, we now needed only 24 cells per car, with a few extra ones to be used in case the 12 cells would not be able to supply sufficient light for a long trip. This system of lighting proved so successful that it was decided to substitute it for gas in the remaining seven parlor cars. The wiring of these cars was commenced at the Meadow shops, near Jersey City, last September, and has just been completed. These cars are arranged for the 23 C type of the Accumulator company's battery and 19 B type of the Julien battery. The battery boxes under the cars are larger than the old style and contain four trays or 16 cells, the lamps we used taking 23 volts of current. Changes were also made the first of the year in the system of charging, and the batteries are now charged from an incandescent dynamo instead of an arc, thus enabling the batteries to be charged with any amount of current desired. In connection with this description of the four years' work of the Pennsylvania railroad, I would like to add something in regard to the electric lighting of the Chicago limited express.

In 1887, the Pullman Palace Car Co. commenced using the electric light on one of three trains of the New York and Chicago limited express, and the charging of the batteries at Jersey City, was given into the hands of the Pennsylvania Railroad Co. The batteries used were the 7 B type of the Electrical Accumulator Co., 30 cells to a car, and usually there were six cars in the train. These batteries would furnish enough light for one trip, and each time the train arrived at either terminus it was necessary to replace them with freshly charged cells. This was not objectionable at Chicago, for the train arrived there in the morning, so that they could be charged during the day, but in Jersey City, where the train did not arrive until evening, the work was very difficult on account of the dynamo being in use for other purposes. After this one train had been running a short time, another one was fitted up, 19 B type of Julien battery being used. It was thought that this would give us a chance to see which was the better of the two batteries, but they both worked very well considering the treatment they received. After Mr. Bauer became connected with the Pullman company, he did away with charging the batteries at the ends of the line, and introduced a Brotherhood engine and Eickemeyer dynamo in the baggage car of each train, in order that the batteries might be charged in transit. When the train leaves Jersey City, the baggage car is on the rear, and consequently no charging is done until it leaves Philadelphia, where the train is reversed, bringing the baggage car next to the locomotive. The batteries are charged continuously until the train reaches Chicago, and the same practice is continued on the return trip. The steam for driving the Brotherhood engine is taken from the locomotive boiler, and the exhaust is used for heating the train.

So far as the Pennsylvania railroad is concerned, the electric lighting of passenger trains may be considered an assured success; and leading as it does to the abolition of kerosene lamps, and incidentally encouraging the adoption of steam heating, the safety and comfort of the passenger is certainly increased.

ARC LAMPS AND THEIR MECHANISM.[1]

BY PROFESSOR SILVANUS THOMPSON, D. SC., M. I. E. E.

(Continued from page 219.)

EQUALIZERS.

In sundry forms of lamp special mechanical devices have been introduced for the purpose of equalizing, throughout a given range of motion, the otherwise very unequal pull of the electro-magnet upon its armature. Set-up springs with adjustable steps have been used for this purpose. A more satisfactory *equalizer* (*repartiteur*) is the device suggested by the famous conjurer, Robert Houdin, which is depicted in figure 1. Here the attraction of the electro-magnet, E, for its armature *a*, is transmitted through a system of two curved levers, A and B, which rock on one another at a point of mutual contact which varies the "mechanical advantage" of the system, and partially or wholly, according to the curvature, compensates for the great increase of force as the distance of the armature diminishes.

The form of the equalizer of Foucault, as used in the Foucault-Duboscq lamp, is depicted in figure 2. Here the armature, *a*, which is stiffly pivoted eccentrically to allow of adjustment, is attached to a lever, A, whose fulcrum is at F, and the opposing force of a spring, *s* (itself adjustable by the screw *r*) is applied through the curved rocking lever B. The vertical arm attached above F carries the detent D. Equalizers depending on use of a rocking lever

1. Paper read before The Society of Arts, London, March 6, 1889.

are to be found in several lamps. [Serrin's lamp; also Mackenzie, 95[82], and Common, 626[82]].

Returning from this digression, we have now to go separately over the eight items of the schedule, and point out how the various necessities have been met by the ingenuity of various inventors. As it is impossible to mention all instances of carrying out a principle, reference is made only to a few cases, preferably to the best known lamps.

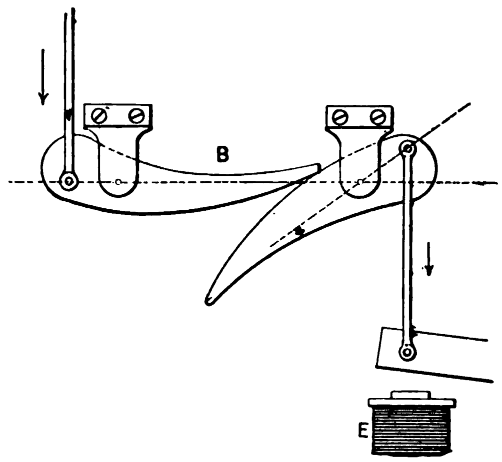


FIG. 1. HOUDIN'S EQUALIZER.

[A]—DRIVING POWER.

The following devices have been used :—

1. *Gravity.*—Descent by its own weight of upper carbon holder [innumerable lamps]; ditto, aided by weights specially attached [Gülcher, 1,915[82]]; ditto, partially opposed by coiled spring to compensate for consumption [Siemens, 366[88]]; clock work driven by weights [Staite, 11,783[47]]; lower carbon floated upward in mercury [Tommasi, 4,405[79]].

2. *Coiled spring.*—Drives by pinion and rack, or pulley and cord [Foucault, 1848, Staite, 11,449[46]]. Differential action of two coiled springs [Foucault-Duboscq lamp].

3. *Electro-magnetic motor.*—(*a*) Suction of core by solenoid; (*b*) electric motor rotates and drives carbon rod [Bousfield, 523[79]; Breguet, &c.]; (*c*) electro-magnetic vibrator drives carbon rod [Clark-Bowman, 1,182[83]; Newton, 1,623[83]; Pieper, 4,133[86]; Holmes, 760[86]].

4. *Hot air.*—Heated air rising from lamp drives fan to propel carbons. [Varley, 5,656[81].]

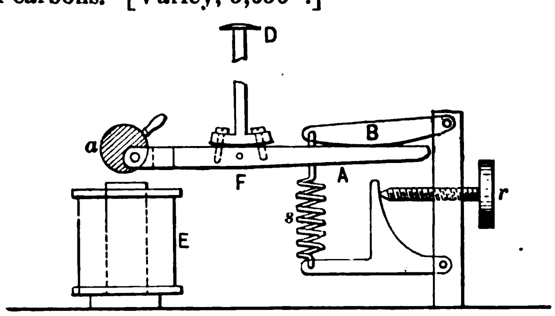


FIG. 2. FOUCAULT'S EQUALIZER.

[B]—STRIKING MECHANISM.

To strike the arc requires mechanical devices; but as these are to be actuated by the current itself, it is appropriate first to consider what electric mechanism is necessary or sufficient to actuate the movement. Assuming that the carbons are initially in contact when there is no current, the current when turned on must part them; the appropriate device is therefore an electro-magnet (or solenoid with its core in lieu thereof) having its coils in the main circuit of the lamp. [Foucault, 1847; Staite, 11,783[47], and in the vast majority of modern lamps.] If, however, the carbons are initially apart, the lamp must itself bring them together; and the appropriate device to actuate this movement will be an electro-magnet (or solenoid) connected as a shunt, and therefore having fine wire coils of high resistance. Such an arrangement will bring the carbons together by the action of the by-pass current, and as this falls almost to zero on the contact of the carbons, they will be at once parted (and the arc struck) by the opposing force; this force may be that of gravity [Lontin, 1875] or a spring [Lever, 2,092[82]; Thomson-Rice, figure 27]. The disadvantage of this second method is that the initial resistance of the whole series of lamps standing with their carbons parted is enormous unless there is a cut-out circuit. Another method of striking the arc is by cutting out a main-circuit electro-magnet [Crompton, 346[82]; Bright, 377[82]].

The modes of parting the carbons are various :—

1. Drawing both carbons asunder by gearing [Foucault-Duboscq lamp].

2. Drawing down the lower carbon by electro-magnet placed in base [Staite, 11,783[47]; Serrin, Breguet, Sellon, Newton, Pieper, Holmes, &c.], or by electro-magnet situated at top [Crompton "E," 1881; Gramme; Silvertown Co.; Fein, 1888].

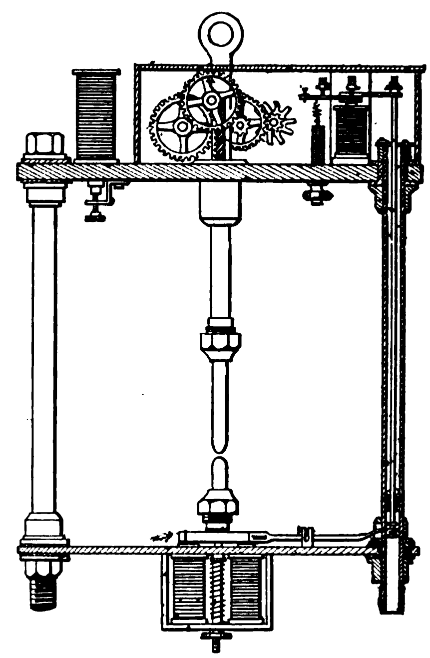


FIG. 3. BREGUET LAMP.

3. Lifting upper carbon rod [Roberts, 14,198[52]; Slater and Watson, 212[52]; and the vast majority of modern lamps, Brush, Siemens, Crompton, Pilsen, Brockie-Pell, Thomson-Houston, &c.], or lifting upper carbon by an electro-magnet situated in the carbon rod [Abdank, 1884]; or by lifting bodily the upper carbon and the whole of the feeding train [Crompton, 346[82]; Fyfe and Main, 3,821[81]; Berjot, Wood, Hochhausen, Maxim, 1,649[80]; Gümpel, 253[81], &c.]; or by rocking the feeding train around a centre [Brockie, 2,370[82]; De Puydt, figure 23, p. 353].

The mechanical devices for performing these various actions are numerous, and their action is complicated by the endeavor of many inventors to cause the same mechanism which initially strikes the arc also subserve the purpose of feeding the carbons. In some lamps, however, these functions are kept separate. An example of a lamp in which the striking and feeding mechanisms are kept separate is afforded by the Breguet lamp (figure 3), in which an electro-magnet draws down the lower carbon holder to strike the arc, whilst the feeding is accomplished in the subsequent gradual descent of the upper carbon. In the lamps of Newton, Sellon, and Holmes, there is used the

special form of short-range electro-magnet (*a* 2 in the list), having a central core and external tube of iron. There is a very numerous class of lamps in which a clutch is caused to grip the upper carbon holder, and then to raise it so as to strike the arc; the same clutch being subsequently so operated, as to permit the carbon holder—a smooth rod —to slide down by degrees as required, to feed the carbon pencil forward. Such devices are best considered under the heading of feeding mechanisms.

The adjustments of the striking mechanism may be of two kinds:—(1) adjustments of range, such as limiting stops and set screws; (2) adjustments of force, such as the regulable spring shown in figure 1 at the bottom.

The main-circuit electro-magnets, and solenoids, used for striking the arc, are wound with a wire of large enough section to carrry the required current without undue heating, and are of small resistance. The weight of copper wire employed varies from one to four pounds; and the resistance varies from 0.05 to 0.2 ohms.

[C]—FEEDING MECHANISM.

The electric devices here differ in the case of lamps for parallel working and lamps for series working.

(*i.*) *For lamps in parallel.*—Assuming that the supply mains are kept at constant potential, then the lamp mechanism must be responsible for keeping the other factor of the electric power, namely, the current through the lamp, at a constant value. That is say, whenever by reason of the burning away of the carbon points the arc grows long, offering more resistance, and, therefore, reducing the current below its normal value, the lamp must automatically feed the pencils forward, and so re-adjust the current. It is obvious that, in this case, the weakening of the current through the lamp may be caused to bring the feeding mechanism into operation by the use of an electro-magnet (or solenoid) in the main circuit. For if the armature of this electro-magnet be held back by a spring or weight which only just counterbalances the pull of the magnet when the current is normal, the weakening of the current will at once cause a movement of the armature which may be utilized to relax a clutch, lift a detent, or release an escapement. And it is also obvious that in this case it is possible to arrange the same electro-magnet which strikes the arc to actuate the feed. Examples of the use of a single main-circuit electro-magnet to actuate both the striking and the feeding mechanisms are to be found in the Serrin lamp, in the Gülcher lamp, and in the Brush lamp as arranged for parallel working.

(*ii.*) *For lamps in series.*—Assuming that the dynamo is doing its duty, and keeping the current constant, then in this case the lamp mechanism must be responsible solely for keeping constant the potential between the terminals. Whenever by reason of the burning away of the carbons the arc lengthens and offers more resistance, if the same current is still supplied to it and forced through this greater resistance, it will burn more brightly, and the difference of potentials between the terminals of the lamp will rise above its normal value. The lamp must then automatically bring its carbons nearer, and re-adjust the potentials to the proper number of volts. It is obvious that the appropriate device to actuate the feeding mechanism must, in this case, be something that can play the part of a voltmeter; and will actuate the mechanism when the volts rise above their normal value. Practical voltmeters are of two kinds; (*i.*) those which depend on the magnetic effects of the current that will flow through a wire of high resistance placed as a shunt across the two points between which the differences of potential exists, and (*ii.*) those which depend on the heating effects of the current in such a wire. Either of these effects may be used to control the feeding mechanism of arc lamps; that is to say, the feed must be controlled by a shunt circuit, which will actuate the mechanism as soon as the potential rises above its normal value. The usual device is an electro-magnet (or solenoid) of fine wire, and of high resistance (from 200 to 400 ohms), the armature of which is counterbalanced by the force of a spring, or by gravity, or by an opposing main circuit electro-magnet (or solenoid). An alternative device, not, however, in general use, is a long thin platinum wire, which when heated by a current above the normal value will expand and actuate the feed. Thermal expansion has been attempted as a method of regulation by several inventors. [Lontin, 2,074^{77}; Siemens, 2,281^{78} and 2,110^{79}; Munro, 1,626^{82}; Edison, 2,072^{82}; Pollak, 1888, &c.]

In the following table are comprised the several electrical arrangements for controlling the feeding mechanism:—

(*i.*) *Constant potential lamps* (*for parallel working*).

(*a*) Series electro-magnet, same as used for striking.
[Serrin; Gülcher; Brush; Crompton, &c.]
(*b*) Series electro-magnet, separate from the striking electro-magnet.
[Fontaine.]
(*c*) Differential arrangement. Series winding partly opposed in shunt winding, on separate cores or parts of mechanism.
[Lacassagne and Thiers, 2,456^{56}; Siemens; Brockie-Pell.]
(*d*) Ditto, but wound on same cores.

(*ii.*) *Constant current lamps* (*for series working*).

(*a*) Shunt electro-magnet alone, acting against gravity or spring.
[Lontin, 1877; Lever.]
(*b*) Shunt electro-magnet separate from the striking (series) electro-magnet.
[Numerous lamps. Breguet (figure 3); Crompton "E"; Sellon; Gramme; Pieper.]
(*c*) Differential arrangement. Shunt winding pulling against series winding, on separate part of mechanism.
[Lacassagne and Thiers; Siemens "differential"; Pilsen; Crompton-Crabb "DD"; Thomson-Houston; Brockie-Pell; Kennedy.]
(*d*) Differential Winding.
[Numerous lamps. Brush; Weston; "Simplex."]

The typical arrangement of circuits for lamps that are to be run on a system of arc lighting in series, is shown in a generalized diagram in figure 4. The striking coil is in the

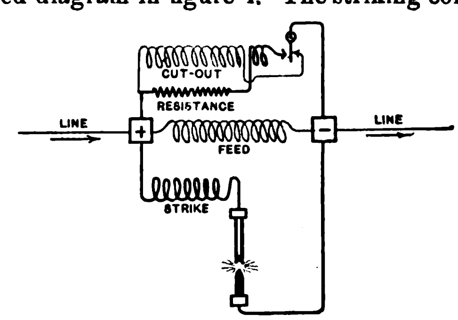


FIG. 4.

main circuit; the feeding coil is a shunt, which if wound on the same core as the series coil in any of the differential systems must be so wound that the currents circulate in opposing senses. There is also added a cut-out circuit, having both a shunt coil and a small series coil; but these must be so wound as to help one another's magnetic power, and the small series coil must itself be a shunt to the main circuit of the lamp.

(*To be continued.*)

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.[1]

BY G. W. DE TUNZELMANN, B. SC.

(Continued from page 224.)

Effects of the approach of dielectrics.—A very rough estimate shows that when a dielectric of large mass is brought near to the apparatus, the quantities of electricity set in motion by dielectric polarization are at least as large

1. From the *Electrician* (London).

as in metallic wires or thin rods. If, therefore, the action of the apparatus were unaffected by the approach of such masses it would show that, in contradiction to the theories of Faraday and Maxwell, no electro-dynamic actions are called into play by means of dielectric polarization, or, as Maxwell calls it, electric displacement. The experiments, however, showed an effect similar to that which would be produced if the dielectric were replaced by a conductor with a very small oscillation period. In the first experiment made, the mass of dielectric consisted of a pile of books, 1.5 meter long, 0.5 meter broad, and 1 meter high, placed under the plates A A′. Its effect was to displace the null points through about 10° towards the pile. A block of asphalt (D, in figure 10), weighing 800 kilogrammes, and measuring 1.4 meter in length, 0.4 meter in breadth, and 0.6 meter in height, was then used in place of the books, the plates being allowed to rest upon it.

The following results were then obtained :—

(1) The spark at the highest point of the circle was now decidedly stronger than that at the lowest point, which was nearer to the asphalt.

(2) The null points were displaced through about 23° downwards—that is, in the direction of the block—and at the same time were transformed into mere points of minimum sparking, a complete disappearance being no longer obtainable.

(3) When the plates A A′ rested on the asphalt block the oscillation period of the primary was increased, as shown by the fact that the period of B had to be slightly increased in order to obtain the maximum sparking distance.

(4) When the apparatus was moved gradually away from the block its action steadily diminished without changing its character.

(5) The action of the block could be compensated by bringing the conductor C over the plates A A′, while they rested on the block, the null points being brought back to *a* and *a′* when C was at a height of 11 centimeters above the plates. When the upper surface of the asphalt was five centimeters below the plates compensation was obtained when C was placed at a height of 17 centimeters above them, showing that the action of the dielectric was of the order of magnitude which had been anticipated.

The asphalt contained about five per cent. of aluminium and iron compounds, 40 per cent. of calcium compounds, and 17 per cent. of quartz sand. In order to make sure that the observed effects were not due to the conductivity of some of these substances, a number of further experiments were made.

In the first place the asphalt was replaced by a mass of the same dimensions of the so-called artificial pitch prepared from coal, and effects of a similar kind were observed, but slightly weaker, the greatest displacement of the null points amounting to 19°. Unfortunately this pitch contains free carbon, the amount of which it is difficult to determine, and this would have some conductivity.

The experiments were then repeated with a conductor, C, of half the linear dimensions of the former one, and smaller blocks of various substances, on account of the great cost of obtaining large blocks of pure materials. The substances used were asphalt, coal-pitch, paper, wood, sandstone, sulphur, paraffine, and also a fluid dielectric, namely, petroleum. With the smaller apparatus it was not possible to obtain quantitative results of the same accuracy as before, but the effects were of an exactly similar character, and left little room for doubt of the reality of the action of the dielectric.

The results might possibly be supposed to be due to a change in the distribution of the electrostatic E. M. F. in the neighborhood of the dielectric, but in the first place Dr. Hertz states that he has been unable to explain the details of the observations on this hypothesis, and in the second place it is disproved by the following experiment :—

The smaller apparatus was placed with the line *r s* on the upper near corner of one of the large blocks, in which position the dielectric was bounded by the plane of the plates A A′ and the perpendicular plane through *r s*, both of which are equi potential surfaces, so that if the action were electrostatic no effect should be produced by the dielectric. It was found, however, to produce the same effect as in other positions. It might also be supposed that the effects were due to a slight conductivity, but this could hardly be the case with such good insulators as sulphur and paraffine. Suppose, moreover, that the conductivity of the dielectric is sufficient to discharge the plate A in the ten-thousandth of a second, but not much more rapidly. Then, during one oscillation, the plates would lose only the ten-thousandth part of their charge, and the conduction current in the substance experimented on would not exceed the ten-thousandth part of the primary current in A A′, so that the effect would be quite insensible.

It was shown in the experiments described in my last paper that when variable electrical forces act in the interior of dielectrics of specific inductive capacity not equal to unity, the corresponding electric displacements produce electro-dynamic effects. In a paper "On the Velocity of Propagation of Electro-Dynamic Actions," in Wiedemann's *Annalen*, vol. xxxiv., p. 551, Dr. Hertz shows that similar actions take place in the air, which proves, as was previously pointed out, that electro-dynamic action must be propagated with a finite velocity.

The method of investigation was to excite electrical oscillations in a rectilinear conductor in the same manner as in former experiments, and then to produce effects in a secondary conductor by exciting electrical oscillations in it by

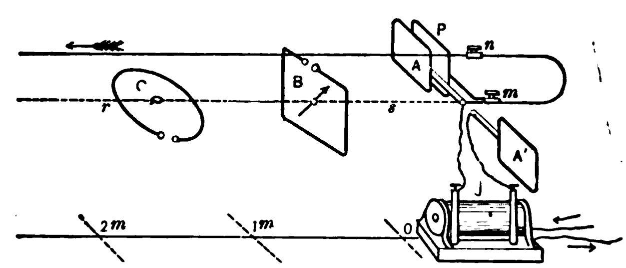


Fig. 11.

means of those in the rectilinear conductor, and at the same time by the primary conductor acting through the intervening space. This distance was gradually increased, when it was found that the phase of the vibrations at a distance from the primary lagged behind those in its immediate neighborhood, showing that the action is propagated with a finite velocity, which was found to be greater than the velocity of propagation of electrical waves in wires in the ratio of about 45 to 28, so that the former is of the same order as the velocity of light. Dr. Hertz was unable to obtain any evidence with respect to the velocity of propagation of electrostatic actions.

The primary conductor A A′ (figure 11) consisted of a pair of square brass plates with sides 40 centimeters in length, connected by a copper wire 60 centimeters in length, at the middle point of which was an air space, across which sparks were made to pass by means of powerful discharges from the induction coil J. The conductor was fixed at a height of 1.5 meter above the base-plate of the coil, with its plates vertical, and the connecting wire horizontal. A straight line, *r s*, drawn horizontally through the air space of the primary and perpendicular to the direction of the primary oscillation will be called the base line, and a point in this situated at a distance of 45 centimeters from the air space will be referred to as the null point.

The experiments were made in a large lecture room, with nothing near the base line for a distance of 12 meters from the primary conductor. The room was darkened during the experiments.

The secondary conductor consisted either of a circular wire, C, of 35 centimeters radius, or of a square of wire, B,

with sides 60 centimeters long. The primary and secondary air spaces were both capable of adjustment by means of micrometer screws. Both the secondary conductors were in unison with the primary, the (half) vibration period of each being 1.4 hundred-millionth of a second, as calculated from the capacity and coefficient of self-induction. It is doubtful whether the ordinary theory of electrical oscillations would lead to accurate results under the conditions of these experiments, but as it gives correct numerical results in the case of Leyden jar discharges, it may be expected to be correct as far as the order of the results is concerned. When the centre of the secondary lies in the base line, and its plane coincides with the vertical plane through the base line, no sparks are observed in the secondary, the E. M. F. being everywhere perpendicular to the direction of the secondary. This will be referred to as "the first principal position" of the secondary. When the plane of the secondary is vertical and perpendicular to the base line, the centre still lying in the base line, the secondary will be said to be in its "second principal position." Sparking then occurs in the secondary when its air space is either above or below the horizontal plane through the base line, but not when it is in this plane. As the distance from the primary was increased the sparking distance was observed to decrease, rapidly at first, but ultimately very slowly. Sparks were observed throughout the whole distance of 12 meters available for the experiments. The sparking in this position is due essentially to the E. M. F. produced in the portion of the secondary remote from the air space. The total E. M. F. is partly electrostatic and partly electro-dynamic, and the experiments show beyond the possibility of doubt that the former is greater, and therefore determines the direction of the total E. M. F. close to the primary, while at greater distances it is the electro-dynamic E. M. F. which is the greater.

The plane of the secondary was then turned into the horizontal, its centre still lying in the base line. This may be called "the third principal position." When the centre of the circular secondary conductor was kept fixed at the null point, and the air space was made to travel round the circle, vigorous sparking was observed in all positions. The sparking distance attained its maximum length of about six millimeters when its air space was nearest to that of the primary, and its minimum length of about three millimeters when the distance between the two air spaces was greatest. If the secondary had been influenced by the electrostatic force, sparking would only be expected when the air space was close to the base line, and a cessation of sparks in the intermediate positions. The direction of the oscillation would, moreover, be determined by the direction of the E. M. F. in the portion of the secondary furthest from the air space. There is, however, superposed upon the electrostatically excited oscillation a second oscillation due to the E. M. F. of induction, which produces a considerable effect since its integral round the circle (considered as a closed circuit) does not vanish; and the direction of this integral E. M. F. is independent of the position of the air space, opposing the electrostatic E. M. F. in the portion of the secondary next to A A′, and assisting it in the portion furthest from A A′, as explained in a previous paper.

The electrostatic and electro-dynamic E. M. F.'s therefore act in the same direction when the air space is turned towards the primary conductors, and in opposite directions when the air space is turned away from the primary. In the latter position it is the E. M. F. of induction which is the more powerful, as is shown by the fact that there is no disappearance of sparking in any position of the air space, for when this is 90 degrees to the right or left of the base line it coincides with a node with respect to the electrostatic E. M. F. In these positions the inductive action in the neighborhood of the primary can be observed, independently of the electrostatic action.

Waves in rectilinear wires.—In order to produce in a wire by means of the primary oscillations a series of advancing waves of the character required for these experiments, the following arrangements were made:—Behind the plate A was placed a plate, P, of equal size. A copper wire one millimeter in diameter connected P to the point M of the base line. From M the wire was continued in a curve about a meter in length to the point N, situated about 30 centimeters above the air space, and was then further continued in a straight line parallel to the base line for such a distance as to obviate all danger of disturbance from reflected waves. In the present series of experiments the wire passed through a window, and after being carried to a distance of about 60 meters was put to earth, and a special series of experiments showed that this length was sufficient. When a wire, bent so as to form a nearly closed circuit with a small air space, was brought near to this straight wire, a series of fine sparks was seen to accompany the discharges of the induction coil. Their intensity could be varied by varying the distance between the plates P and A. The waves in the rectilinear wire were of the same period as that of the primary oscillations, as was proved by their being shown to be in unison with each of the two secondary conductors previously described. The existence of stationary waves showed that the waves in the rectilinear wire were of a steady character in space as well as in time. The nodal points were determined in the following manner:—The further end of the wire was left free, and the secondary conductor was brought near to it, in such a position that the wire lay in its plane, and had the air space turned towards it. As the secondary was moved along the wire, points of no sparking were observed to recur periodically. The distance from the point *n* to the first of these was measured, and the length of the wire made equal to a multiple of this distance. The experiments were then repeated, and it was found that the nodal points occurred at approximately equal intervals along the wire.

The nodes could also be distinguished from the loops in other ways. The secondary conductor was brought near to the wire, with its plane perpendicular to it, and with its air space neither directed completely towards the wire nor completely away from it, but in an intermediate position, so as to produce E. M. F.'s perpendicular to the wire. Sparks were then observed at the nodes, while they disappeared at the loops. When sparks were taken from the rectilinear wire by means of an insulated conductor, they were found to be stronger at the nodes than at the loops; the difference, however, was small, and was, indeed, scarcely distinguishable unless the position of the nodes and loops was previously known. The reason that this and other similar methods do not give a well-defined result lies in the fact that irregular oscillations are superposed upon the waves considered; the regular waves, however, can be picked out by means of the secondary, just as definite notes are picked out by means of a Helmholtz resonator. If the wire is severed at a node, no effect is produced upon the waves in the portion of wire next to the origin; but if the severed portion of wire is left in its place, the waves continue to be propagated through it, though with somewhat diminished strength.

The possibility of measuring the wave lengths leads to various applications. If the copper wire hitherto used is replaced by one of different diameter, or by a wire of some other metal, the nodal points retain their position unchanged. It follows from this that the velocity of propagation in a wire has a definite value independent of its dimensions and material. Even iron wires offer no exception to this, showing that the magnetic susceptibility of iron does not play any part in the case of such rapid motions. It would be interesting to investigate the behavior of electrolytes in this respect. In their case we should expect a smaller velocity of propagation, because the electrical motions are accompanied by motions of the molecules carrying the electric charges. It was found that no propagation of the waves took place through a tube 10 millimeters in diameter, filled with a solution of sulphate of

copper; but this may have been due to the resistance being too high. By the measurement of wave lengths the relative vibration periods of different primary conductors can be determined, and it therefore becomes possible to compare in this manner the vibration periods of plates, spheres, ellipsoids, etc.

In the experiments made by Dr. Hertz, nodes were very distinctly produced when the wire was severed at a distance of either 8 meters or 5.5 meters from the null point of the base line. In the first case the nodes occurred at distances from the null point of — 0.2 meter, 2.3 meters, 5.1 meters, and 8 meters, and in the latter case at distances of —0.1 meter, 2.8 meters and 5.5 meters. It appears, therefore, that the (half) wave length in a free wire cannot differ much from 2.8 meters. The fact that the wave lengths nearest to P were somewhat smaller was to be expected from the influence of the plates and of the curvature of the wire. This wave length, with a period of 1.4 hundred-millionths of a second, gives 200,000 kilometers per second for the velocity of propagation of electrical waves in wires. Fizeau and Gounelle (Poggendorff's *Annalen*, vol. lxxx., page 158, 1850) obtained for the velocity in iron wires 100,000 kilometers per second, and 180,000 in copper wires. W. Siemens (Poggendorff's *Annalen*, vol. clvii., page 309, 1876), by the aid of Leyden jar discharges, obtained a velocity of from 200,000 to 260,000 kilometers per second in iron wires. Dr. Hertz's result is very nearly the mean of these, from which we may conclude that the order at any rate, of the vibration period as calculated by him is correct. The value obtained cannot be regarded, independently of its agreement with experimental results otherwise obtained, as a fresh determination of the velocity, since it rests upon a theory which is open to doubt.

Interference of the direct actions with those transmitted through the wire.—If the square circuit B is placed at the null point in the second principal position, with the air space at its highest point, it will be unaffected by the waves in the wire, but the direct action when in this position was found to produce sparks two millimeters in length. B was then turned about a vertical axis into the first principal position in which there would be no direct action of the primary oscillation, but the waves in the wire gave rise to sparks, and by bringing P near enough to A, a sparking distance of two millimeters could be obtained. In the intermediate positions sparks were produced in both these ways, and it would therefore be possible to get a difference of phase, such that one should either increase or diminish the effect of the other. Phenomena of this nature were, indeed, observed. When the plane of B was in such a position that the normal drawn towards A A′ was directed away from that side of the primary conductor on which P was placed, there was more sparking than even in the principal position; but if the normal were directed towards P, the sparks disappeared, and only reappeared when the air space was made smaller. When the air space was at the lowest point of B, the other conditions remaining the same, the sparks disappeared when the normal was turned away from P. Further variations of the experiment gave results in accordance with these.

It is easily seen that these phenomena were exactly what were to be expected. To fix the ideas, suppose the air space to be at the highest point and the normal directed towards P, as in figure 11. Consider what happens at the moment that the plate A has its greatest positive charge. The electrostatic, and therefore the total E. M. F., is directed from A towards A′. The oscillation to which this gives rise in B is determined by the direction of the E. M. F. in the lower portion of B. Therefore positive electricity will flow towards A′ in the lower portion, and away from A′ in the upper portion.

Consider next the action of the waves. As long as A is positively charged, positive electricity will flow from the plate P. This current is, at the moment considered, at its maximum value at the middle point of the first half wave-length. A quarter of a wave-length further from the origin—that is to say, in the neighborhood of the null point—it first changes its direction. The E. M. F. of induction will here, therefore, impel positive electricity towards the origin. A current will therefore flow round B towards A′ in the upper portion and away from A′ in the lower portion. The electrostatic and electro-dynamic E. M. F.'s are therefore in opposite phases and oppose each other's action. If the secondary circuit is rotated through 90°, through the first principal position, the direct action changes its sign, but not so the action of the waves, so that they now tend to strengthen each other. The same reasoning holds when the air space is at the lowest point of B.

Greater lengths of wire were then included between m and n, and it was found that the interference became gradually less marked, until with a length of 2.5 meters it disappeared entirely, the sparks being of equal length whether the normal were directed towards or away from P. When the length of wire between m and n was further increased, the distinction between the different quadrants reappeared, and with a length of four meters the disappearance of the sparks was fairly sharp. The disappearance, however, then took place (with the air space at the highest point) when the normal was directed away from P, the opposite direction to that in which the disappearance previously took place. With a still further increase in the length of the wire the interference reappeared and returned to its original direction with a length of six meters. These phenomena are clearly to be explained by the retardation of the waves in the wire, and show that here again the direction of motion in the advancing waves changes its sign at intervals of about 2.8 meters.

To obtain interference phenomena with the secondary circuit C in the third principal position the rectilinear wire must be removed from its original position, and placed in the horizontal plane through C, either on the side of the plate A, or of the plate A′. Practically it is sufficient to stretch the wire loosely and to fix it by means of an insulated clamp on each side of C, alternately. It was found that when the wire was on the same side as the plate P, the waves in it diminished the previous sparking, and when on the opposite side the sparking was increased, both results being unaffected by the position of the air space in the secondary circuit. Now it has been already pointed out that at the moment when the plate A has its maximum positive charge and at which, therefore, the primary current begins to flow from A, the current at the first node of the rectilinear wire begins to flow away from the origin. The two currents therefore flow round C in the same direction when C lies between the rectilinear wire and A, and in opposite directions when the wire and A are on the same side of C. The fact that the position of the air space is indifferent confirms the conclusion formerly arrived at, that the direction of oscillation is that due to the electrodynamic E. M. F. These interferences are also changed in direction when the wire m n, one meter in length, is replaced by a wire four meters in length.

Dr. Hertz also succeeded in obtaining interference phenomena when the centre of the secondary circuit was not in the base line, but these results were of no special importance, except that they confirmed the previous conclusions.

Interference phenomena at various distances.—Interference may be produced with the secondary at greater distances than that of the null point, but care must then be taken that the action of the waves in the wire is of about the same magnitude as the direct action of the primary circuit through the air. This can be effected by increasing the distance between P and A.

Now, if the velocity of propagation of the electrodynamic disturbances through the air is infinite, the interference will change its sign at every half-wave length in the wire—that is to say, at intervals of about 2.8 meters. If the velocities of propagation through the air and through the wire are equal, the interference will be in the same

direction at all distances. Finally, if the velocity of propagation through the air is finite, but different from the velocity in the wire, the interference will change in sign at intervals greater than 2.8 meters.

The interferences first investigated were those which occurred when the secondary circuit was rotated from the first into the second principal position, the air space being at the highest point. The distance of the secondary from the null point was increased by half-meter stages from 0 up to 8 meters, and at each of these positions an observation was made of the effects of directing the normal towards and away from P, respectively. The points at which no difference in the sparking was observed in the two positions of the normal are marked 0 in the table below. Those in which the sparking was least, showing the existence of interference, when the normal was directed towards P, are marked +, and those in which the sparking was least when the normal was directed away from P are marked —. The experiments were repeated with different lengths of wire *m n*, varying by steps of half a meter from one meter up to six meters. The first horizontal line in the table gives the distances in meters of the centre of the secondary circuit from the null point, while the first vertical line gives the lengths of the wire *m n*, also in meters.

TABLE I.

	0		1		2		3		4		5		6		7		8
100	+	+	0	—	—	—	—	—	0	0	0	0	0	+	+	+	+
150	+	0	—	—	—	—	0	0	0	0	0	+	+	+	+	+	0
200	0	—	—	—	—	—	0	+	+	+	+	+	0	0	0	0	0
250	0	—	—	—	—	0	0	+	+	+	+	0	0	0	0	0	0
300	—	—	—	—	0	+	+	+	+	+	0	0	0	0	—	—	—
350	—	—	0	+	+	+	+	+	+	0	0	0	—	—	—	—	—
400	—	—	0	+	+	+	+	0	0	0	0	—	—	—	—	—	—
450	—	0	+	+	+	+	+	0	0	0	—	—	—	—	—	—	0
500	—	0	+	+	+	+	0	—	—	—	—	—	0	0	0	0	+
550	0	+	+	+	+	0	0	—	—	—	—	—	0	0	0	0	+
600	+	+	+	+	0	0	—	—	—	—	—	0	0	+	+	+	+

An inspection of this table shows, in the first place, that the changes of sign take place at longer intervals than 2.8 meters; and, in the second place, that the change of phase is more rapid in the neighborhood of the origin than at a distance from it. As a variation in the velocity of propagation is very unlikely, this is probably due to the fact indicated by theory that the electrostatic E. M. F. which is more powerful than the electro-dynamic E. M. F. in the neighborhood of the primary oscillation, has a greater velocity of propagation than the latter.

In order to obtain a definite proof of the existence of similar phenomena at greater distances Dr. Hertz continued the observations, in the case of three of the lengths *m n*, up to a distance of 12 meters, and the result is given in the table below :—

TABLE II.

	0	1	2	3	4	5	6	7	8	9	10	11	12
100	+	0	—	—	0	0	0	+	+	+	+	+	0
250	0	—	—	0	+	+	0	0	0	0	—	—	—
400	—	0	+	+	0	0	—	—	—	—	0	0	0

If we make the assumption that at the greater distance it is only the E. M. F. of induction which produces any effect, the experiments would show that the interference of the waves excited by the E. M. F. of induction with the original waves in the wire changes its sign only at intervals of about seven meters.

In order to investigate the E. M. F. of induction close to the primary oscillation, where the results are of special importance, Dr. Hertz made use of the interferences which were obtained when the secondary circuit was in the third principal position, and the air space was rotated through 90° from the base line. The direction of the interference at the null point, which has already been considered, was taken as a negative, the interference being considered positive when it was produced by the passage of waves on the side of C remote from P, which makes the signs correspond with those of the previous experiments. It must be borne in mind that the direction of the resultant E. M. F. at the null point is opposed to to that of the E. M. F. of induction, and therefore the first table would have begun with a negative sign if the electrostatic E. M. F. could have been eliminated. The present experiments showed that up to a distance of three meters interference continued to occur, and always of the same sign as at the null point. It was unfortunately impossible to extend these observations to a greater distance than four meters, on account of the feebleness of the sparks, but the results obtained were sufficient to give distinct evidence of a finite velocity of propagation of the E. M. F. of induction. These observations, like the former ones, were repeated with various lengths of the wire *m n*, in order to exhibit the variation in phase, and the results obtained are given in the table below :—

TABLE III.

	0	1	2	3	4
100	—	—	—	—	0
150	—	—	0	0	0
200	0	0	0	+	+
250	0	+	+	+	+
300	+	+	+	+	+
350	+	+	+	+	0
400	+	+	+	+	0
450	+	+	+	0	0
500	+	+	0	0	0
550	+	0	0	0	—
600	0	—	—	—	—

which shows that as the distance increases the phase of the interference changes in such a manner that a reversal of sign takes place at intervals of from seven to eight meters. This result is further confirmed by comparing the results of table iii. with the results for greater distances given in table ii., for in the former series the effect of the electrostatic E. M. F. is eliminated owing to the special position of the secondary circuit, while in the former it becomes insensible at the greater distances owing to its rapid decrease with increasing distance. We should therefore expect the results given in the first table for distances beyond four meters to follow without a break the results given in table iii. for distances up to four meters. This was found to be the case, as is evident from inspection of tables ii. and iii.

To show this more clearly the signs of the interference of the waves, due to the electro-dynamic E. M. F., with the waves in the wire, are collected together in table iv., the first four columns of which are taken from table iii., and the remaining columns from table ii.

TABLE IV.

	0	1	2	3	4	5	6	7	8	9	10	11	12
100	—	—	—	—	0	0	0	+	+	+	+	+	0
250	0	+	+	+	+	+	0	0	0	0	—	—	—
400	+	+	+	+	0	0	—	—	—	—	0	0	0

From the results given in this table the author draws the following conclusions :—

(1) The interference does not change its sign at intervals of 2.8 meters. The electro-dynamic actions are therefore not propagated with an infinite velocity.

(2) The interference is not in the same phase at all points. Therefore the electro-dynamic actions are not propagated through air with the same velocity as electric waves in wires.

(3) A gradual retardation of the waves in the wire has the effect of displacing a given phase of the interference towards the origin of the waves. The velocity of propagation through the air is therefore greater than through a wire.

(4) The sign of the interference is reversed at intervals of 7.5 meters, and therefore in traversing this distance an electro-dynamic wave gains one length of the waves in the wire.

Thus, while the former travels 7.5 meters, the latter travels $7.5 - 2.8 = 4.7$ meters, and therefore the ratio of the velocities is 75 : 47, which gives for the half-wave length of the electro-dynamic action $2.8 \times 75/47 = 4.5$ meters. Since this distance is traversed in 1.4 hundred-millionths of a second, the absolute velocity of propagation through the air must be 320,000 kilometers per second. This result can only be considered reliable as far as its order is concerned; but its true value can hardly exceed half as much again, or be less than two-thirds of this amount. In order to obtain a more accurate determination of the true value it will be necessary to determine the velocity of electric waves in wires with greater exactness.

It does not necessarily follow from the fact that in the immediate neighborhood of the primary oscillation the interference changes its sign after an interval of 2.8 meters that the velocity of propagation of the electrostatic action is infinite, for such a conclusion would rest upon a single change of sign, which might, moreover, be explained, independently of any change of phase, by a change in the sign of the amplitude of the resultant force at a certain distance from the primary oscillation. Quite independently, however, of any knowledge of the velocity of propagation of electrostatic actions, there exist definite proofs that the rates of propagation of electrostatic and electro-dynamic E. M. F's are unequal.

In the first place the total force does not vanish at any point on the base line. Now, near the primary the electrostatic E. M. F. is the greater, while the electro-dynamic E. M. F. is the greater at greater distances. There must, therefore, be some point at which they are equal, and since they do not balance they must take different times to reach this point.

In the second place, the existence of points at which the direction of the resultant E. M. F. becomes indeterminate does not seem capable of explanation, except on the supposition that the electrostatic and electro-dynamic components perpendicular to each other are in appreciably different phases, and, therefore, do not compound into a rectilinear oscillation in a fixed direction. The fact that the two components of the resultant are propagated with different velocities is of considerable importance, in that it gives an independent proof that one of them at any rate must have a finite velocity of propagation.

(To be continued.)

THE RELATION BETWEEN THE INITIAL AND AVERAGE EFFICIENCY OF INCANDESCENT ELECTRIC LAMPS.[1]

BY WM. H. PEIRCE.

At the present day there is very little reliable published information relative to the variation with age of the economy and light-giving power of incandescent lamps. However well this law of variation may be known to lamp experts, the author believes himself to be justified in saying that the majority of electrical engineers are entirely unacquainted with it. The most complete data, and the latest, at least in this country, is that given in a report in 1885, to the Franklin Institute, by a committee appointed to test lamps and dynamos. At that time the successful commercial lamp was but two or three years old, and since then the development of lighting by incandescence has been so remarkable as to cause this lamp test to now be almost ancient history. When considering the possibilities of incandescent lighting in depots, offices and shops, the fact of the absence of trustworthy records of late date induced the following investigation to be made by the author in the interest of the Chicago, Burlington & Quincy Railroad Co.

There were in all 94 lamps studied, embracing four of the most prominent makes of lamps on the market. Fifty-nine of these were purchased—15 each of three kinds and 14 of one type of lamp. Care was exercised to obtain the commercial lamp. After the preliminary measurements had been made upon these 59 lamps, the local agents for them were invited to make an examination of the test room and of the methods pursued. As an outcome of their visits the remaining 35 lamps were upon their solicitation tested. These lamps were in every case sent direct from their respective factories especially for this test, which fact I am rather prone to construe as a vote of confidence by the various lamp companies in our system of measurements.

The Howell voltmeter was used for determining the volts in all measurements, and the following is a brief description of its principle.

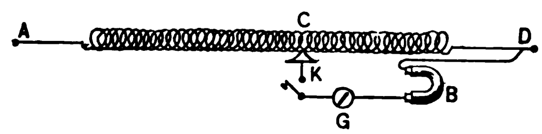


Fig. 1.

The pressure to be measured is caused to drop through the resistance A D, figure 1, equal to about 4,500 ohms, and a Daniell cell, B, is so arranged that when the key K is closed the electromotive force between C D is opposed by that of the battery, and hence no current passes through the galvanometer G, when the electromotive force between C and D is equal to that of the cell. In practice the rider C is moved along the resistance until no current flows through the galvanometer, and the electromotive force between A D is then determined from the formula :—

$$V = v\,\frac{R}{r} = 1.08\,\frac{R}{r};\ \text{where}$$

V = Volts between $A\ D$.
v = Volts between $C\ D$ = electromotive force of cell.
R = Resistance $A\ D$ in ohms.
r = Resistance $C\ D$ in ohms.

Naturally the completed instrument avoids this calculation for each observation by having the rider C move along a scale reading to volts. With the instrument used it was found that when the rider pointed to 110 volts that $R = 4{,}493$ and $r = 44.4$, and hence $V = 109.3$. Similarly, when the instrument read 100 volts, the true reading should have been 99.4, and so when making observations a correction of .6 volt was applied. The electromotive force of the cells was 1.08 volt, as determined at the laboratory of the Edison Lamp Works. The correctness of our voltage indications being thus dependent upon the battery, a standard liable to variation, it was decided to frequently obtain new cells direct from the Lamp company's laboratory. In the early part of the test considerable care was exercised in comparing the voltmeter with four or five others at hand, and just before starting the duration test four new cells were obtained, and at intervals others were added, as shown by the following table, until 10 in all were had. In table i., the cells are numbered from 1 to 10, in the order of their obtainment. Those cells which checked with one another are marked O. K. The last received cells were always assumed to be correct, and where the old cells differed from them the amount of variation is given in per cent. of the electromotive force of the cell.

1. A paper read before the American Institute of Electrical Engineers, May 22, 1889.

TABLE I.

Cell Number.	Dec. 27, 1888.	Jan. 8, 1889.	Jan. 15.	Jan. 26.	Feb. 11.	Feb. 27.	March 14.	April 1.	April 29.
1.	O. K.	O. K.	O. K.	O.K.	O. K.	O. K.	5/8% low	1¼% low	1¼% low
2.	O. K.	O. K.	Low	Low	Low	Low	5/8% low	3/8% low	1% low
3.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	½% low	1% low	1% low
4.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	½% low	¾% low	1% low
5.				O. K.	O. K.	O. K.	½% low	½% low	½% low
6.				O. K.	O. K.	O. K.	O. K.	O. K.	O. K.
7.							O. K.	O. K.	O. K.
8.							O. K.	broken	
9.									O. K.
10.									O. K.

In this table it is shown that on December 27, and January 8, all four cells were apparently correct—that is, they check with one another. That on January 15, three cells out of four; January 26, February 11, February 27, five of six cells; March 14, three of eight cells; April 1, two of seven cells, and April 29, four of the nine cells were O. K. And further, that the maximum variation at any time between any two cells was 1¼ per cent. It is thus seen that we are reasonably assured that our electromotive force was practically constant.

The cells were mounted on a switch-board, so that any two or all of them could be connected in multiple series by inserting plugs, and they were compared with each other by rapidly substituting first one and then another of the cells in the voltmeter while measuring the electromotive force of the test-room circuit. The last two or three cells received were always used when making determinations on lamps.

The ammeter was of the Bergman solenoid type, having a range of from 0.2 to 1.0 ampere. The readings of the instrument were calibrated at the beginning of the test by copper voltameters, the $Cu\ SO_4$ solution of which had a specific gravity approximating 1.16, and the area of the cathode was four square inches per ampere measured. The coulomb equivalent was taken as .0003288 gr. The arrangement for calibration was as sketched in figure 2, where A is the ammeter, L a lamp to consume the electrical energy, P a voltameter, and R an adjustable resistance for keeping the pressure uniform at the lamp terminals, as indicated by the voltameter, and hence to insure constancy of current. The circuit through the voltameters was kept closed for 15 minutes as timed by a stop watch. Extreme care was exercised in preparing the plates and the preventing of oxidation between weighings. The following table shows the current indicated by the ammeter and that obtained by the voltameters in the last made calibration by copper voltameters.

TABLE II.

Readings of ammeter.	Readings of voltameters.		Readings of ammeter.	Readings of voltameters.	
.300	.297	.296	.700	.692	.692
.350	.350	.347	.750	.745	....
.400	.399	.398	.800	.791	.796
.450	.450	.451	.850	.844	.840
.500	.493	.493	.900	.898	.894
.550	.549	.545	.950	.947	.948
.600	.588	.588	1.000	.994	.993
.650	.635	.641			

This table shows that the ammeter was calibrated at every .05 of an ampere from .3 to 1.0 ampere, and that the maximum variation between the voltameter and ammeter readings was about .01 ampere, and that generally the two readings checked to within .005 ampere.

After these determinations the scale was changed to such an extent as was estimated would correct the readings of the ammeter.

The photometer was a 60-inch bar, Letheby-Bunsen, in combination with the Methven two-candle slit. The Methven standard was accompanied by a certificate signed by Mr. John Methven, stating that a two-candle power light was emitted through the slit, when the quality of the gas used was such as to give from 15 to 20 candles with a flame three inches high. In order to prove the correctness of this standard when using Chicago gas, a comparison with Sugg's

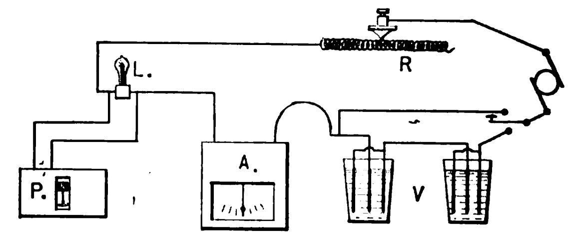


Fig. 2.

standard sperm candles was instituted. Ten different candles were used, two at a time, and the observations were made in accordance with the rules of the London gas referees. Table iii., shows that the Methven standard varied less than one per cent. from the power of two standard sperm candles; this conclusion being based upon 100 observations.

TABLE III.

Comparison of Methven's standard two-candle slit with Sugg's standard candles.

Series.	Number of candles.	Brand of candles.	Grains of sperm burnt.	Rate of burning sperm per hour for one candle.	Time of making observations.	Average of 10 readings.	Corrected average reading.
1....	2	Sugg's.	40	118.0	10′ 10¼″	1.968	1.936
2....	2	"	40	114.8	10′ 28½″	2.034	1.942
3...	2	"	40	116.1	10′ 20¼″	2.064	1.998
4....	2	"	40	114.6	10′ 27¼″	2.010	1.920
5....	2	"	40	114.8	10′ 28½″	2.080	1.984
6....	2	"	40	114.9	10′ 26″	2.140	2.050
7....	2	"	40	118.8	10′ 6¼″	2 080	2.008
8....	2	"	40	119.2	10′ 4½″	2.038	2.024
9....	2	"	40	114.2	10′ 31″	2.068	1.966
10....	2	"	40	113.8	10′ 33″	2.066	1.960
Grand average of 100 observations 1.984							

It was recognized that in a test of this kind the four factors most liable to variation were the voltage, the current readings, the standard of light and the personal errors of the observers. It was considered that the most certain and most practicable way in which to guard against such errors would be to measure the candle-power, the voltage and the current upon several lamps, and to put these lamps aside to be used only as reference lamps. Accordingly five lamps, which had previously been allowed to burn at an abnormal voltage for nearly 100 hours, had for them the above several quantities determined, and the correctness of the apparatus and personal readings were checked up by the reference lamps whenever observations on the test lamps were about to be made. Table iv. exhibits the readings of these lamps. It will be seen that the candle-power determinations vary from about four per cent. below to four per cent. above the first readings made on the lamps, and hence this table proves conclusively that the conditions of the test were essentially the same at all times of its duration. In addition it may be said that for the determination of the candle-power of these lamps the mean of five observations at the same point was always taken.

TABLE IV.

Readings of reference lamps.

Date.	Lamp No. 1 101 volts. C. P.	Amperes.	Lamp No. 2 101 volts. C. P.	Amperes.	Lamp No. 3 100 volts. C. P.	Amperes.	Lamp No. 4 100 volts. C. P.	Amperes.	Lamp No. 5 100 volts. C. P.	Amperes.
1.2.89	9.94	.505	9.24	.490	9.40	.480	9.94	.495	9.08	.490
1.8.—	10.10	.505								
1.11.—	10.20	.505								
1.15.—	10.20	.500	9.30	.495	9.40	.483				
1.16.—	10.30	.500								
1.26.—	9.80	.500	9.80	.490						
2.11.—	9.55	.500	8.90	.485	9.30	.485				
2.27.—	9.92	.500								
2.28.—	9.66	.500								
3.14.—			9.30	.490						
3.15.—	10.20	.505			9.80	.485				
4.1.—	9.90	.500								
4.29.—	9.70	.505					10.1	.500	9.8	.490

The lamp test was started in August, 1888, at which time all instruments were calibrated, and preliminary measurements were made on quite a number of lamps. On account, however, of press of other work, the test was shortly afterwards dropped until late in December. All apparatus and lamps remained during this interval untouched in the test room, and when again taking up the subject in December, the continued correctness of the instruments was proven by the fact that some 10 or 12 lamps tested out then as previously.

In the preliminary measurements of new lamps—the resistance cold—the mean horizontal candle-power and the watts of electrical energy consumed were determined, and from these were deduced the watts per candle, and the candles per electrical horse-power.

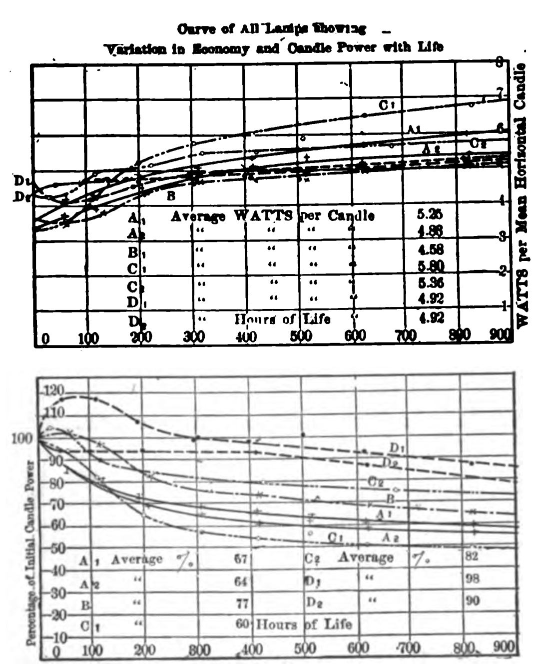


PLATE I

In this paper the candle-power of a lamp is taken to be the mean of 12 points, 30 degrees apart in the horizontal plane of the lamp. The observed candle-power is the power of the lamp at a point in the horizontal plane at right angles to the plane of the base of the filament. The reduction factor is the ratio of the mean horizontal to the observed candle-power.

In the preliminary measurements three readings were made at the point where the observed candle-power readings were to be made, and the lamp was marked so that this point could always in the future be determined. The lamp was then revolved upon its principal axis, and two observations were made every 30 degrees, the starting point, when again reached, also having two more readings made. The five readings made at the starting point were averaged, and the result called the observed candle-power; the observed candle-power and the readings at the other 11 points were then averaged, and this result called the mean horizontal candle-power.

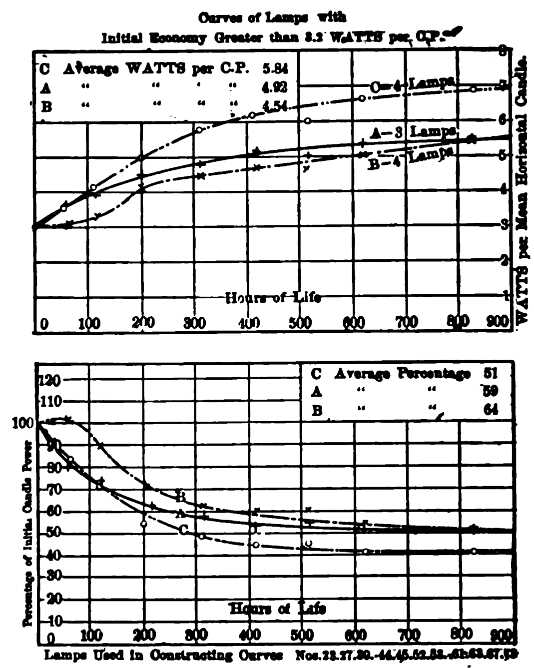


PLATE II

The wire connections to the lamp in the photometer were the same as shown in figure 2, excepting that no voltameters were in circuit.

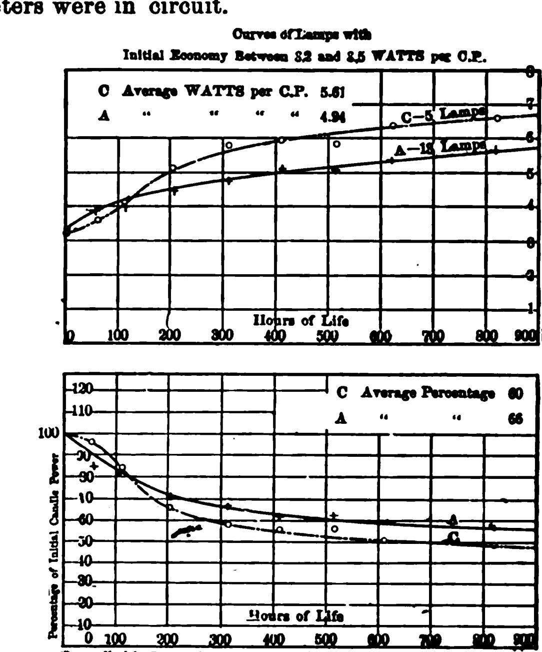


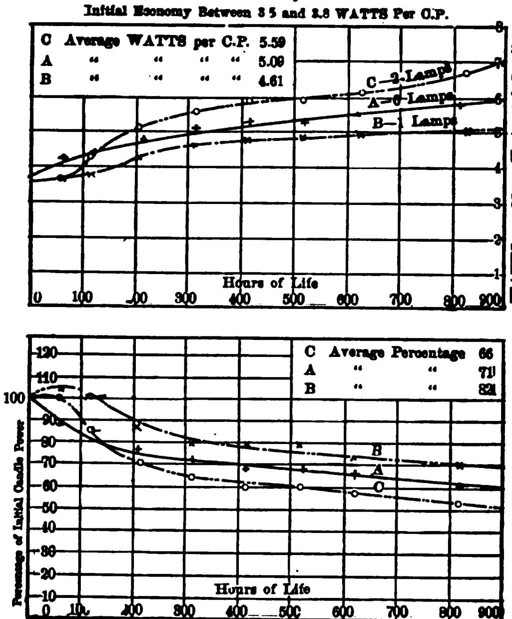
PLATE III

A sliding curtain was hung from the two photometer screen boards, and an opening was maintained only sufficiently wide to permit the reading of the disc. Two screens of deep blue glass were so placed as to shield the person making the candle-power determinations from all glare of the lights. Two observers made the measurements. The author made the photometric readings and regulated the

height of the gas flame, always looking at the flame through deep blue glass, and an assistant placed the lamps in position, adjusted the voltage, made ampere readings, and recorded all observations.

The candle-power readings were always the mean of at least two observations, and if these two differed from each

Curves of Lamps With
Initial Economy Between 3.5 and 3.8 WATTS Per C.P.



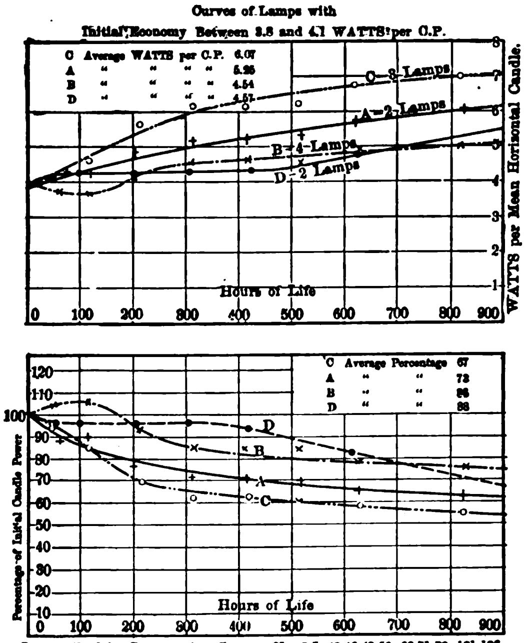
Lamps Used in Constructing Curves Nos.3.4.7.10.11.22.-47.-64.69.

PLATE IV

other more than four per cent., several others were made, and a mean of all observations taken as the correct reading.

A small room, 13 by 19 feet, in which to conduct the test was partitioned off about 40 feet from the dynamos. In this room were located the photometer and other instruments, and all test lamps. The door leading to this apartment was kept locked, no one being allowed to enter during my absence except the engineer in charge of the plant, who twice a day inspected for broken lamps. The photograph of a portion of the room shows the method of hanging the lamps. They were wired in groups of 10 and 15. Lamps of similar marked volts were placed together.

Curves of Lamps with
Initial Economy Between 3.8 and 4.1 WATTS per C.P.

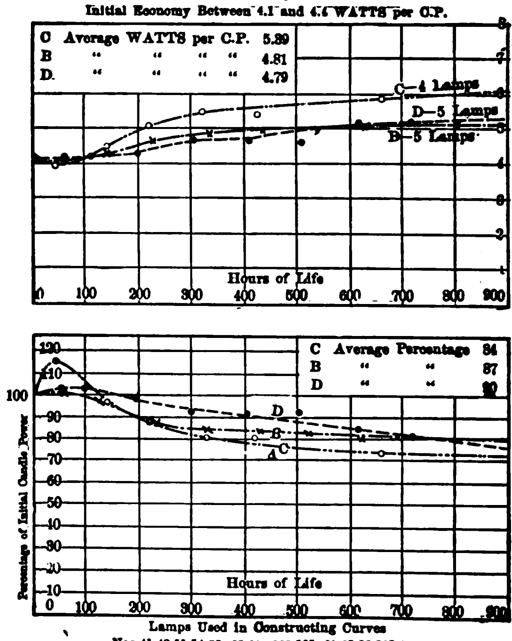


Lamps Used in Constructing Curves Nos.2.5.-43.46.49.50.-66.71.72.-121.126

PLATE V

The volts labeled on the lamps by the manufacturers was taken as being the correct pressure at which to run the lamps. Suitable resistance was introduced into those circuits which required a less pressure than 110 volts, the normal pressure of the house circuits. No lamps were permitted nearer to each other than 12 inches, for fear of

Curves of Lamps With
Initial Economy Between 4.1 and 4.4 WATTS per C.P.

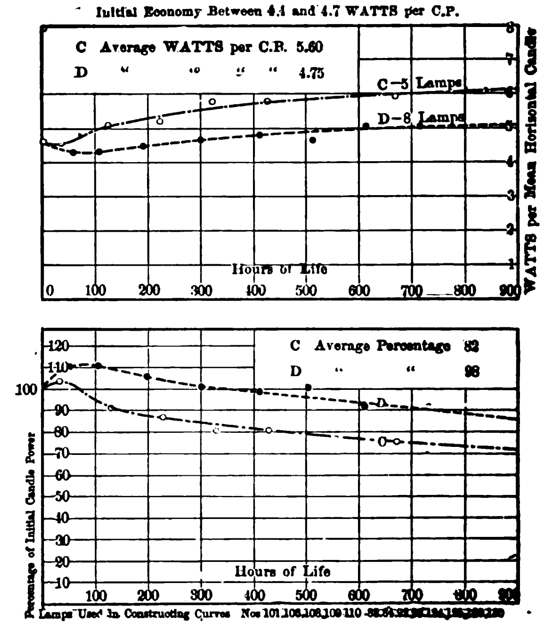


Lamps Used in Constructing Curves
Nos.41.48.51.54.55.-65.102.108.105.-81.85.90.128.127.

PLATE VI

possible harm occurring to one from the heat of the others. The temperature of the air when all lamps were burning was about 104 degrees Fahrenheit, as indicated by a thermometer near the centre of the room. The current was turned off and on the lamps during the first 550 hours in a gradual manner, such as was due to the starting and stopping of the dynamo, but after this time arrangements were made to also have the lamps switched off and on, once or twice daily, so that the filaments would receive the shock of sudden heating and cooling as in usual practice. Excepting when photometric measurements were being made, the lamps burned whenever the dynamos ran, which was gen-

Curves of Lamps with
Initial Economy Between 4.4 and 4.7 WATTS per C.P.



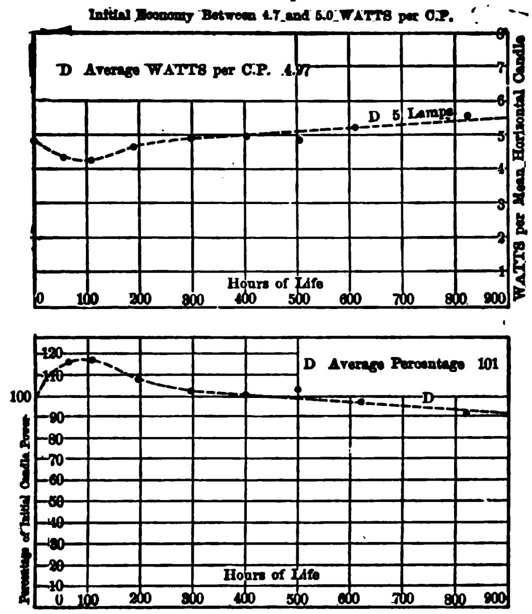
Lamps Used in Constructing Curves Nos 101.106.108.109 110

PLATE VII

erally 9 hours per diem, 4¾ hours in the morning and 4¼ hours in the afternoon, with one hour intervening. In the mains leading to the test room was interposed a variable resistance coil by which the pressure at the lamps could be adjusted independently of that of the house circuit. Two pressure indicators were connected with the test lamps, one Howell governing the engineer, and one of the United States Electric Light Co.'s pattern in the office of the superintendent of telegraph. In the latter place was a push button with which to ring a bell and thus call the attention of the engineer if the voltage varied immoderately. As a matter of fact, the pressure was generally within one volt of the normal as shown by the indicators, which instruments were from time to time adjusted of any variations found between them and the voltmeter in the test room. A written statement was daily sent in by the engineer as to the exact hours of burning and the failure of lamps.

The duration test was started January 2, 1889, and was continued until April 29, 1889, thus permitting those lamps first entered to burn about 820 hours. The lamps contributed by the various companies did not burn this long, because when they were received the test on the purchased lamps was about 200 hours under way.

Curves of Lamps With
Initial Economy Between 4.7 and 5.0 WATTS per C.P.



Lamps Used in Constructing Curves Nos.32.57.91.94.128.

PLATE VIII

It was aimed to make candle-power and efficiency measurements of the lamps after they had lived 55, 110, 200, 300, 400, 500, 600 and 850 hours.

In the accompanying curves each make of lamp is designated by a letter. A_1, B_1, C_1, and D_1 have reference to the purchased lamps; A_2, C_2, D_2, indicate those tested at the request of the lamp companies. In either case similar letters refer to like make of lamps.

Three series of curves have been constructed. In the first of these, plate i., is shown the variation with age in the economy and candle-power of all the lamps. Each curve represents a batch of from 10 to 15 lamps; thus the C_1 lines relate to the 15 lamps purchased, and the C_2 curves indicate the influence of life upon the lamps contributed by the C lamp company.

The upper set of curves illustrate the economy of the several lamps at their different periods of life. Thus the A_1 curve indicates that these 15 A lamps when new, consumed 3.54 watts per mean horizontal candle, that after 900 hours 6.1 watts of electrical energy were necessary to produce one candle-power of light; and, further, that during 900 hours the mean economy of the lamps was 5.25 watts per candle-power.

The lower diagrams indicate the effect of age upon the light-giving power of the lamps. Thus the A_1 curve demonstrates that these A lamps after 900 hours gave but 58½ per cent. of the initial candle-power, and that the mean intensity of light during 900 hours was 67 per cent. of the new lamps.

In the construction of the second series of curves, plates ii. to viii., inclusive, the lamps have been divided into groups according to their initial economy. Thus, A, 2 and 5; B, 43, 46, 49, 50; C, 66, 71, 72, and B, 121 and 126, are all lamps consuming when new from 3.5 to 3.8 watts per candle, and have been used to construct plate v. We have seven sets of comparative curves, the various lamps in each set having approximately the same initial economy.

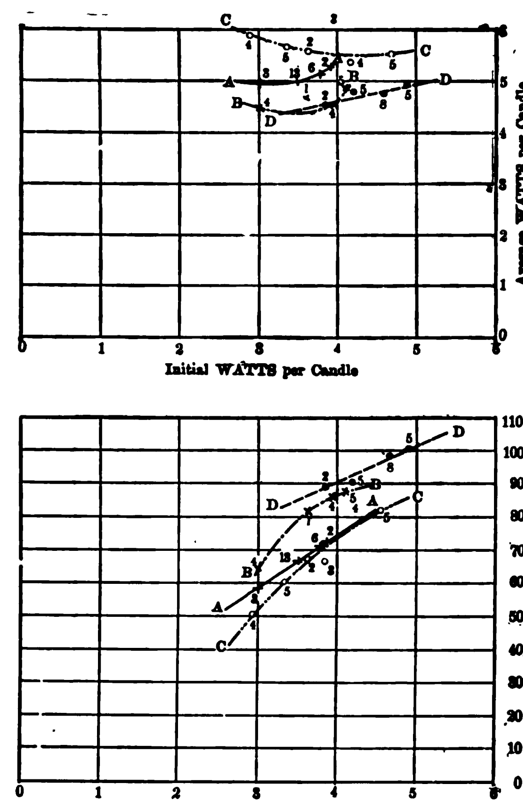


PLATE IX

In the third series, plate ix., we have a summation of all previous diagrams and tables. These curves show the relation between the initial and average efficiency of the incandescent electric lamps studied. These curves are plotted with the initial economy of the lamps as abscissæ, and the corresponding averages deduced from the preceding curves as ordinates. The figures at the plotted points have reference to the number of lamps used in determining each point.

From these curves we learn that the varying of the initial economy between the limits of three and five watts per candle does not greatly affect the average economy, but it does have a very marked effect upon the average candle-power derived from the lamp.

THE EFFICIENCY OF THE ARC LAMP.[1]

BY HATSUNÉ NAKANO.

NOTE.

The interesting results recently obtained by Mr. Merritt in the application of the method of Melloni to the investigation of the efficiency of the incandescent lamp, have

1. A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889, with an introductory note by Edward L. Nichols.

made it seem desirable to extend that method to the study of the arc lamp also.

Existing data concerning the efficiency of this source of light are exceedingly imperfect, being based chiefly upon measurements with the Bunsen photometer. Ordinary photometric determinations of the light-giving value of sources of illumination differing widely in temperature from the standard candle are necessarily at fault; and I have endeavored in a recent paper[2] to call attention anew to the character of the errors involved in the comparison of the light of the electric arc with that of other sources of artificial illumination.

The efficiency of the arc lamp has been expressed hitherto in terms of the candle-power of light produced per unit of energy expended. The estimate has been based in a few instances upon the mean spherical candle-power, as actually determined; more frequently upon the candle-power emanating from the lamp in a single, especially selected direction, and in too many instances upon the "nominal candle-power." Such estimates of the efficiency of the arc are of small value. They afford us widely varying results which cannot be definitely compared; and even when they are based upon the most complete and careful determinations of candle-power and energy, they do not indicate the ratio of light-giving radiation to the total energy expended within the lamp. It seemed, therefore, to be of some importance to obtain measurements of the ratio of luminous to total radiation in the case of the arc lamp by a method the results of which would be directly comparable with those already obtained for the incandescent lamp.

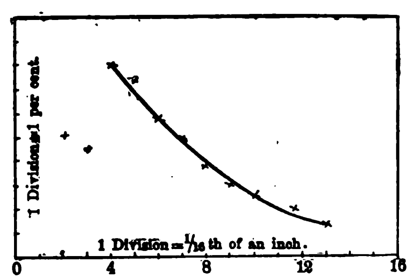


Fig. 1.

The investigation was undertaken, at my suggestion, by Mr. Hatsuné Nakano, M. E., of the Imperial University of Japan, the results of whose measurements are given in the following pages. E. L. N.

ON THE EFFICIENCY OF THE ARC LAMP.

The following experiments were made in the Physical Laboratory of Cornell University during the winter of 1888–89, the object in view being to determine the efficiency of the arc lamp.

It is a well-known fact that the comparison of the candle-power of differently colored lights, such as the candle and the electric arc, is only a rough approximation. By means of one of the methods recently described by Mr. Merritt,[3] however, we can determine the efficiency of the arc independently of its candle-power. The method in question enables us to find the ratio of the light-giving radiation to that of the total radiation of the lamp.

In his first experiments Mr. Merritt measured the heat given out by a lamp, which was immersed in the water contained in a calorimeter. It is evident that this method, though very ingenious, cannot be employed conveniently in the case of the arc lamp. His second method is, however, applicable to arc lamps as well as to incandescent lamps. This method and the arrangement of the apparatus were fully described by Mr. Merritt in his paper, read before the American Association for the Advancement of Science at their meeting in Cleveland. It was also described by Professor Nichols, in his paper read before the American Institute of Electrical Engineers, March 12, 1889.

The application of the method to the arc lamp was as follows:—The rays of the lamp were allowed to fall upon the face of a delicate thermopile which was in circuit with a sensitive galvanometer. The deflection of the galvanometer was taken as a measure of the energy of the total radiation which fell upon the face of the pile.[4] After the deflection due to the total radiation had been measured, a glass vessel of rectangular shape one decimeter thick, containing a strong solution of alum, was placed between the lamp and the thermopile, and the reduced deflection of the galvanometer observed. The use of the alum cell was to cut off the "dark heat," and allow only the rays of the visible spectrum to reach the face of the thermopile. But a certain small percentage of the longer wave-lengths passed through, and a considerably larger percentage of luminous rays were cut off by the cell. To determine the correction for the former source of error, a cell containing an opaque solution of metallic iodine in bisulphide of carbon was placed between the lamp and the alum cell. Any deflection now obtained was due to the dark rays passing through the alum cell, for the iodine cut off the luminous rays entirely, but allowed the dark rays to pass through. It was found that the dark rays which passed through the alum cell were exceedingly weak—almost imperceptible in most cases.

The correction for the second source of error, viz., the absorption of the luminous rays by the alum cell, was determined photometrically. The average of some 30 measurements gave 26 per cent. for the value of the correction.

In my first measurements, the lamp (the centre of the arc) and the thermopile were placed in the same horizontal plane. The lamp used was a "rack-feed" arc lamp requiring 45 volts and nine amperes for its normal operation. Experiments were made with a dozen or more of different sizes of carbons, ranging from 2-16 up to about 13-16 inch in diameter.

The efficiency, or the ratio of the energy of the luminous radiation to that of the total radiation, luminous and non-luminous, in this plane was found to be exceedingly small, varying from about five per cent. to a little less than 15 per cent., the ratio increasing as the diameter of the carbons used decreased. This relation between the efficiency and the diameter of the carbons, which is shown graphically by means of the curve in figure 1, ceased to exist, however, when the point was reached at which the whole length of the carbons was rendered hot by the current passing through them. After this point was reached the efficiency fell off again.

Table i. gives the results of these measurements. In the first column the diameters of the carbons (in thousandths of an inch) are given. The second column shows the "mean horizontal efficiency;" that is to say, the ratio of the deflection produced by the total radiation of the lamp to that due to the light-giving radiation alone, after the proper corrections for absorption and diathermancy have been applied. Each value is the mean of a series of observations. The third column gives the potential difference between the terminals of the lamp.

2. The Efficiency of Methods of Artificial Illumination. Transactions of the American Institute of Electrical Engineers, No. 5, vol. 6.

3. Ernest Merritt: Some Determinations of the Energy of the Light from Incandescent Lamps. *American Journal of Science*, vol 37, p. 167.

4. John Ericsson in his "Contributions to the Centennial Exhibition," 1876, says that the calorific energy imparted to a thermopile is not proportional to the arcs through which the needle of the galvanometer sweeps, as stated by Melloni, but that for deflections not exceeding 15 degrees, the calorific energy imparted to the pile by radiant heat is very nearly as the square root of the versed sine of the angle of deflection; the deflection of the needle at the termination of the first degree exceeding the energy transmitted, in the ratio of 100 to 89, and beyond 90 minutes the energy becoming greater than the deflection in a constantly increasing ratio. Ericsson does not state, however, what kind of galvanometer he used in his investigations. The one used by me was a low resistance reflecting galvanometer of Sir William Thomson's pattern. It had been tested by Mr. Merritt, who found that the deflections were proportional to the energy imparted to the pile. In my experiments this proportionality was assumed to be true.

TABLE I.

Diameter of carbons. (In inches.)	Horizontal efficiency.	P. D. (Volts.)
.832	.01484	42
.730	.02162	45
.605	.02527	43
.563	.03125	38
.500	.03893	38
.432	.05014	38
.370	.05861	28
.305	.07338	31
.250	.0813	56
.185	.0458	25
.124	.0514	30

The curve given in figure 1, shows the relation between the efficiency, measured in the horizontal plane, and the diameters of the carbons. The ordinates represent efficiencies, and abscissæ the diameters. It will be noticed

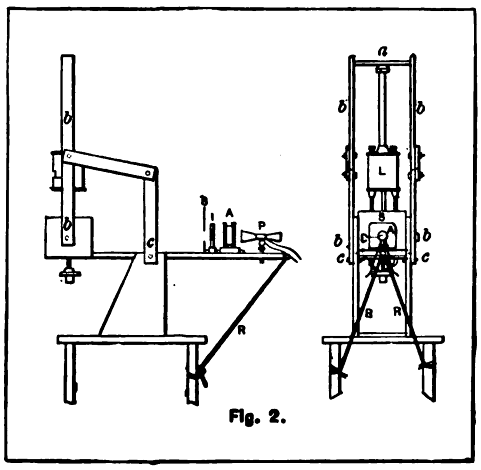


Fig. 2.

that the points A and B, corresponding to 2-16 and 3-16 inch carbons, are far below the curve, showing that the relation is modified as soon as the carbons become too small to carry the current without heating.

In the electric arc, as Professor Nichols has shown in the paper already referred to, "the entire light-giving area is included between the line surrounding the positive carbon, which is at red heat, and the corresponding line upon the negative carbon. Now the surface of total radiation is much larger than that from which the light-giving rays emanate. It includes in addition to the incandescent surfaces near the arc, all those portions of the carbons which

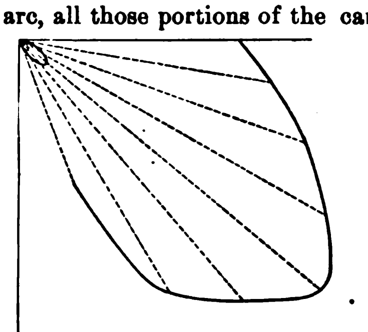


Fig. 3.

are heated, either by conduction or by the current. Were the distribution of total radiation in the vertical plane identical with that of the light-giving rays, the measurement of their ratio with the axis of the thermopile in any plane which passes through the arc would give us the efficiency of the lamp, but the curve of distribution of total intensity is not the same as that of candle-power, and the ratio in question is a function of the angle which the axis of the pile makes with the horizon. It becomes necessary, therefore, to make an exploration of the entire zone through which the lamp sends out rays, determining the ratio of luminous to total radiation for each angle and then to integrate the results."[5]

5. Edward L. Nichols, l. c.

With such an object in view the piece of apparatus which is shown in figure 2, was devised. The lamp was hung from a horizontal beam (*a*), supported by two upright pieces (*b b*), which could be kept always vertical by means of a "parallel motion" arrangement. The alum bath (A) and the thermopile (P) were also carried upon a board, pivoted at (*c c*), so that it could be turned to any desired angle. All necessary changes of angle could be made without altering the distance between the arc and the thermopile, or the relation of the alum cell to either

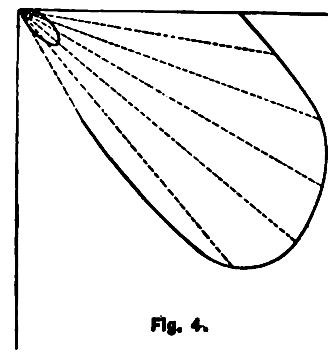


Fig. 4.

of them. By means of this apparatus, measurements were made at angles of 0°, 10°, 20°, 30°, 40°, 50°, 60° and 63° below the horizontal planes. The following carbons were used :—

(1)	Uncoated carbons...............	diameter =	.832″
(2)	" "	"	.563″
(3)	Copper-plated carbons..........	"	.500″
(4)	" "	"	.450″
(5)	Uncoated carbons...............	"	.370″
(6)	Copper-plated carbons..........	"	.250″

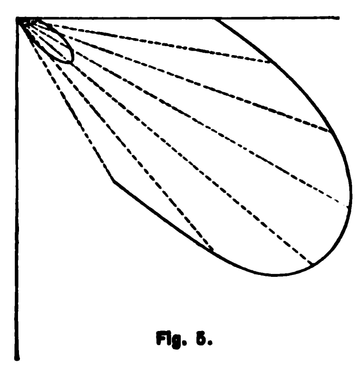


Fig. 5.

The results of these measurements are given in tables ii., iii., iv., v., vi., and vii., and curves showing the distribution of luminous and total radiation, emanating from the lamp under the above conditions, are given in figures 3, 4, 5, 6, 7 and 8.

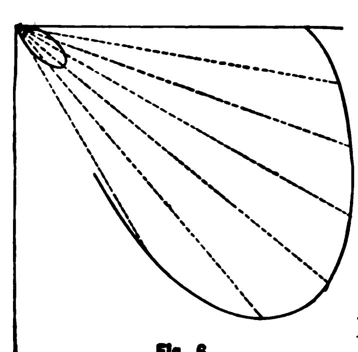


Fig. 6.

The radii show the positions for which measurements were taken, and distances measured along these lines from the origin to each curve give the intensity of luminous and total radiation in each position. The curves of luminous radiation are similar in form to those of candle-power. Note, for purposes of comparison, the set of curves of candle-power

at various angles published by M. Schreihage,[1] of the Polytechnic School at Braunschweig, who has made extended measurements of lamps with different sizes of carbons. In the following tables D is the deflection for total radiation, d that for light-giving radiation (corrected).

TABLE II.

Carbon (unplated), diam. = .832 *inch.*

Angle.	*d.*	*D.*	$\frac{d}{D}$	*P. D.* (Volts).
0°	4.	220	.0182	44
10°	6.8	265	.0256	42
20°	16.4	300	.0547	42
30°	27.3	350	.0780	40
40°	35.1	390	.0900	40
50°	27.3	330	.0827	38
60°	20.3	300	.0677	39
63°	5.4	125	.0432	39

TABLE III.

Carbon (unplated), diam. — .563 *inch.*

Angle.	*d.*	*D.*	$\frac{d}{D}$	*P. D.* (Volts)
0°	6.8	165	.0412	41
10°	10.8	195	.0554	42
20°	22.9	245	.0956	43
30°	32.8	264	.1242	39
40°	39.2	274	.1441	42
50°	28.4	252	.1137	41
60°	10.8	128	.0625	40

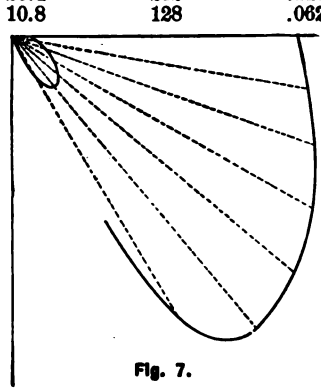


Fig. 7.

TABLE IV.

Carbon (copper-plated), diam. — .5 *inch.*

Angle.	*d.*	— *D.*	$\frac{d}{D}$	*P. D.* (Volts).
0°	5.4	110	.0491	45
10°	12.2	140	.0872	45
20°	21.5	172	.1250	45
30°	29.7	190	.1563	45
40°	33.6	195	.1733	45
50°	20.3	155	.1310	45
60°	4.1	93	.0441	45

TABLE V.

Carbon (copper-plated), diam. — .45 *inch.*

Angle.	*d.*	*D.*	$\frac{d}{D}$	*P. D.* (Volts).
0°	10.8	197	.0548	45
10°	20.3	225	.0901	45
20°	29.7	242	.1228	45
30°	39.2	260	.1506	45
40°	41.9	270	.1552	45
50°	27.3	255	.1059	45
60°	12.2	180	.0676	45
63°	5.4	110	.0492	45

TABLE VI.

Carbon (unplated), diam. — .37 *inch.*

Angle.	*d.*	*D.*	$\frac{d}{D}$	*P. D.* (Volts).
0°	10.	180	.0555	40
10°	14.9	190	.0789	42
20°	24.4	200	.1220	38
30°	31.8	217	.1474	37
40°	39.2	230	.1696	40
50°	42.	240	.1750	42
60°	33.8	205	.1659	42
63°	10.8	115	.0869	38

1. Schreihage, Centralblatt für Elektrotechnik, No. 22, 1888. See also *La Lumière Electrique*, T. 29, page 585.

TABLE VII.

Carbon (copper-plated), diam. — .25 *inch.*

Angle.	*d.*	*D.*	$\frac{d}{D}$	*P. D.* (Volts).
0°	13.5	160	.0844	37
10°	22.9	185	.1238	37
20°	39.2	225	.1742	39
30°	45.9	255	.1800	38
40°	41.9	230	.1822	38
50°	29.7	150	.1980	39
60°	4.1	75	.0547	38

The distribution of total radiation differs widely from that of luminous radiation, so that the efficiency expressed by their ratio depends upon the angle of measurement. The values of the efficiency in each case for the various

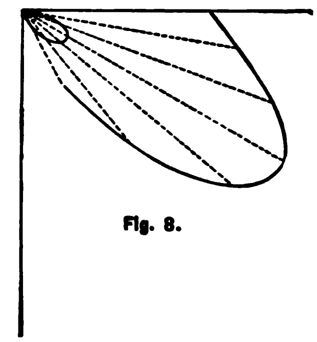


Fig. 8.

angles at which measurements were made have been calculated. They are shown in the diagram of efficiencies in figure 9.

In order to determine the mean or "hemispherical" efficiency of the lamp, the ratio of the radii of two semicircles, the areas of which equal the areas of the curves of total and luminous radiation was found by means of a planimeter. The following are the values thus obtained:—

TABLE VIII.

Diameter of carbons.	Spherical efficiency.
.832	.0687
.563	.1100
.500	.1266
.450	.1330
.370	.1554
.250	.1660

The above table forms the basis of the curve shown in figure 10, which represents the relation between the diameter of the carbons and the "hemispherical" efficiency of the lamp. The diagram is a straight line. Thus we see that the hemispherical efficiency varies inversely as the diameter of the carbon.

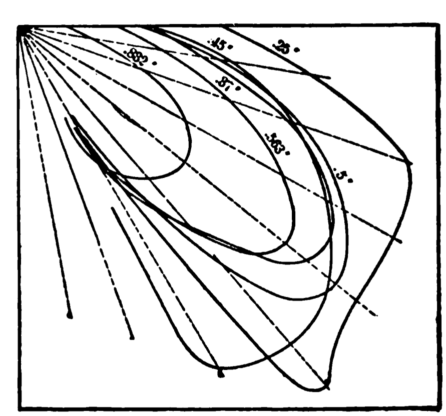


Fig. 9.

It will be interesting to compare this with the result of M. Schreihage's experiments. He measured the mean spherical candle-power with the different sizes of carbons,

and found the same relation to hold true, as will be seen from the following table :—

TABLE IX.

M. Schreihage's measurements of candle-power and current density.

Cross-section of positive carbon. mm.	Diameter. d. mm.	Spherical. c. p.	d. × c. p.	Current density.
40	7.12	417	3,858	0.134
95	11.0	383	3,128	0.066
134	13.6	254	3,462	0.047
194	16.1	189	3,045	0.032
254	18.0	161	2,905	0.25

M. Schreihage states that this relation is not completely satisfied in the case of the mean horizontal candle-power,

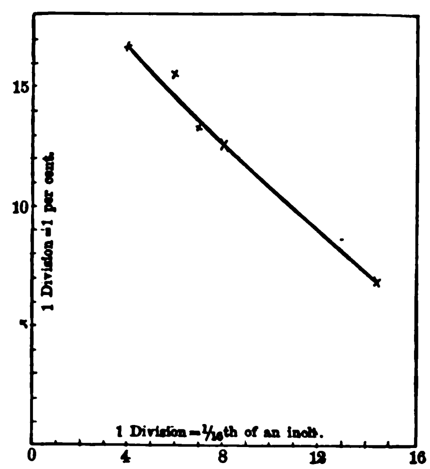


Fig. 10.

especially when the carbons are very small or very large. We have seen that this statement applies also to the experiments upon the horizontal efficiency described in the first part of this paper.

Physical Laboratory of Cornell University, May 6, 1889.

ABSTRACTS AND EXTRACTS.

ACCURACY IN MECHANICAL CONSTRUCTION.[1]

AFTER remarking that the association had made much progress during the past year, Mr. Dixon went on to say that the term "accuracy" is a relative one only, and depends upon our powers of estimating how near a piece of work approximates to actual perfection, for it is well known that there is no such thing as absolute perfection. Intimately mixed with this question of accuracy is that of measurement, for of our powers to detect differences comes our true appreciation of the term accuracy. To have acquired this power of detecting and measuring differences of the highest degree of refinement, is to have acquired a very considerable knowledge of the objects under comparison, and of the errors entering into such measurements. He then dwelt on the various degrees in the accuracy of measurement required by various trades, showing that there was an ascending scale in different occupations, trades and professions. He thought that a scientific interpretation rather than an instinctive one must be the guiding hand in the future. In considering this question of accuracy, it is well not to mix it with the important element of design; for a construction may be of the very highest degree of accuracy, and yet be very indifferent in design, so that he would not consider the general question, but only that power to produce perfectly a piece of mechanism precisely as the designer intended it. Mr. Dixon then pointed out that in all designs only a few simple geometric forms were used, which were limited to those which can be produced with accuracy and despatch. Of these there were: 1, The true plane or flat surface; 2, the true cylindrical form, which may, of course, be either external or internal, the one being simply the counterpart of the other; 3, the true screw; 4, the cone, intimately related to the cylinder, and of necessity external or internal; 5, the sphere, which again has its counterpart, as in the ball and socket joint; 6, irregular forms, some of necessity, as in cams, others as matters of taste in design. With reference to the true plane, it was curious to reflect that even in our boasted perfection of mechanical skill we have to take refuge to hand labor whenever we wish to attain the highest degree of perfection. Only a few weeks ago the speaker had a problem presented to him by a prominent engineer, in that he required a machine for producing absolutely true surfaces, as in the various slides of lathes, without the slightest necessity for hand labor upon them; and although he did not wish to close the door and say it was impossible, yet he could only reply in those terms. After referring to the paper of Sir Joseph Whitworth, read in 1840, on "Plane Metallic Surfaces or True Planes," and showing how largely the scraper was essential, the author said that among machine tools the true plane becomes of extreme importance, and in the planing machine this is perhaps best seen; for not only does the accuracy of the work depend upon the truth of the main slides of the table, but the inaccuracies of the surfaces of the cross slides are exactly reproduced upon the work. In shaping and slotting machines we easily see the controlling influence of the true plane; but it does not stop here, for in all cases where it is necessary to guide a tool or a piece of work in straight lines, it is necessary to resort to the true plane as the sole basis of such control; in fact, we have scarcely a single machine in which the primary accuracy does not depend upon some sliding action. In the milling machine this accuracy is of even greater importance, for owing to the peculiar strains brought upon the slides by the action of the cutter, it needs the highest degree of accuracy to prevent vibrations being set up, which are well known to be fatal to good work. Reference was then made to an extremely delicate little instrument called a spherometer, used in Sir Howard Grubb's works, of Dublin, for the measurement of the accuracy of surfaces; for although it is there used to measure the accuracy of those large spherical surfaces of lenses used in telescopes, it is equally capable of measuring the truth of a plane surface. It consists of a tripod, the feet of which are hardened steel points, and arranged equi-distant from each other. In the centre is a fine pointed steel screw, having 50 threads to the inch, with a micrometer head having 100 divisions, so that each division represents an advancement of $\frac{1}{5000}$th of an inch; but even more delicate forms are constructed. During a recent visit to Dublin, Sir Howard Grubb very kindly showed the action of this instrument, which, in the hands of such a skilled operator, is capable of easily measuring variations of $\frac{1}{50000}$, or even so little as $\frac{1}{1000000}$th of an inch. When the central screw is advanced until all the four steel points have equal pressure, the instrument may be moved to any other part of the surface; and if an elevation amounting to $\frac{1}{100000}$th part of an inch be discovered, it will spin round on the centre point resting on the elevation. So delicate was this little appliance, that the elevation of a glass surface caused by the heat from a touch of the hand was easily shown. In dealing with the true cylinder, it was remarked that the cylindrical is by far the most general form, arising from the simplicity and economy with which it can be produced. Its relative importance is well seen in any works by noting the number of machines, such as lathes, boring and drilling machines, producing cylindrical work, compared with those producing any other form; or, again, by measuring the

1. Abstract of the presidential address read by Mr. S. Dixon, December 12, 1888, before the Manchester Association of Engineers (England). Reprinted from *Industries*.

areas of cylindrical surfaces in any machine. A very obvious advantage in the production of cylindrical surfaces is that the cutting can always be continuous, whereas in that of plane surfaces, except in milling machines, it is intermittent. It was unfortunately true that in many workshops accuracy was ignored, and tools were used which could only be made to produce accurate work by the skill of the workman. How many turners can trust the lathe upon which they are working? Who does not know of a lathe which "slides in" or "slides out," or "bores a bit taper," or "runs off" in surfacing? necessitating the constant adjustment of the tool by the workman, and producing a series of cones, and not a cylinder at all. What often struck him was the remarkable skill with which some men can produce good work on some of those constructions which pass by the name of lathes, and it was often matter for wonder why so many continue to pay so heavily throughout the whole lifetime of a lathe for this extraordinary skill on the part of the workman to avoid the initial errors of the lathe itself; and was it not a strange sight, to see a workman struggling for 20 years to counteract the initial inaccuracies of the lathe put into his hand? From the commercial point of view, the course indicated was a folly, and was clearly proved so. The next simple and extremely useful form was that of the cone, in the production of which the same cardinal principles hold as for the true cylinder. This is now, however, best produced by a combination of motion in two directions, the old practice of displacing and disturbing the accuracy of the movable headstock being the least satisfactory method of producing a true cone. In dealing with the screw, Mr. Dixon remarked that the true screw can only be produced economically from another equally true screw, so that whatever errors exist in the parent screw are reproduced upon the work, and often in an exaggerated form; hence the importance of a true standard screw. If one of the screws which pass muster as guide or standard screws were examined, it would be often found that, although perhaps measuring accurately in pitch over a number of feet, it is full of inaccuracies in different parts of its length. Although these are not easily detected, it is possible to show that in one part the pitch may be lagging behind, and in another in advance of the true pitch. In astronomical and high class philosophical instrument work, an extremely high degree of accuracy was necessary in screw cutting, the question of temperature being highly important. In the screws reproduced by dies also there was much inaccuracy, and it was essential to have good master taps. The metric system of measurement was referred to, and the speaker held that, for general convenience, the English measurement was superior. The problem of dividing circles into equal parts was referred to, and it was remarked that to divide the circle into any number of equal parts has been a problem for mathematicians for ages past; but in the present day it has become an exceedingly important one, for it becomes absolutely necessary to face the general problem of how to divide the circle, not into given numbers, but into any number of equal parts; and although this can now be satisfactorily accomplished, its accuracy is ultimately found to depend upon that of a master wheel. In cases of extreme accuracy required in astronomical instruments, the practice of Sir Howard Grubb is most interesting. In the cutting of wheels, he begins by first dividing the blank to be cut with the extremely delicate dividing engine used for the great circles of telescopes, and having cut these fine lines on the rim, he places the blank in a comparatively strong wheel cutting machine, using the master wheel only for turning round, and not for dividing. Fixed to the machine is a small microscope with cross wires, so that the fine lines of the divisions on the blank can be accurately brought round in succession, and made to coincide accurately with the cross lines of the microscope. The relative importance of a true master wheel is easily seen if we compare its diameter with the diameter of the wheels to be produced. Now, any error of the master wheel is, of course, magnified in wheels of larger diameter made from it, and if to its inaccuracies be added those due to the dividing apparatus, of whatever form it may be, it is highly creditable to engineers that some of those immense toothed wheels now employed in heavy mill gearing have attained such great perfection. One of the finest master wheels he knew of in this country is the one made by the late Mr. Bodmer. It has 360 teeth, and is about six feet diameter, though he was not aware of the means he took to eliminate the errors and insure its extreme accuracy. At the present day the practice of making large wheel patterns is discontinued and superseded by the wheel moulding machine, and whilst rejecting the inaccuracies found in old wood patterns, need we not look very sharply after these new machines which are the parents of all our wheels, for they are working in the foundry under very unfavorable circumstances. The elasticity of various materials ought to be borne in mind, especially in preparing the foundations for machines, and their subsequent erection. The inaccuracies left in the machine tool produced similar or exaggerated errors in the work made from it, and it therefore seemed almost a crime to leave initial seeds of inaccuracies in these constructions, which, by perpetuating themselves for all times, must earn the curses of generations unborn.

Mr. Dixon, in concluding an interesting address, referred to the fact that in the vicinity of Manchester there was probably more accurate construction than in any other district of equal area in the world, and said that the low priced and inaccurately made tools often exported did much to injure the reputation of Englishmen. In conclusion, he said that a special appeal should be made to the younger engineers to maintain that reputation for accuracy which our predecessors have so worthily handed to us.

THE ELECTRICAL TREATMENT OF SEWAGE.[1]

There is a universal consensus of opinion in large towns, and in a good many small ones too, that "something must be done" with the sewage other than turning it into the nearest stream. In many places "something" has been done; the results have always been costly, and we have yet to learn that they have ever been quite satisfactory. In the metropolis vast sums have been spent and are still being laid out upon works for carrying on the precipitation process introduced by Mr. W. J. Dibdin, the chemist to the late Board of Works. This process consists in the precipitation of the solids in the sewage by the addition of 3.7 grains of lime and one grain of sulphate of iron to each gallon of fluid. By this means the matter in suspension is precipitated as mud; the clear liquid is allowed to flow into the river, while the sludge is carried out to sea by steamers and deposited in deep water. There are plenty of chemists who do not hesitate to declare positively that these quantities of chemical are quite insufficient to produce a satisfactory effluent, and that if they are not increased the condition of the Thames will undergo no amelioration. Experience can only decide this point; the works are being built, and the exact method to be followed remains to be determined. It is to the interest of Londoners that the river should be rescued from its present state of filth, and that it should be done as cheaply as is compatible with efficiency.

Among the many processes of sewage purification which are being offered for adoption at the new works by the London County Council, none appears to be more promising than that of Mr. William Webster, of 8 St. Martin's place, Trafalgar square. An experimental plant, capable of treating 1,000,000 gallons of sewage per day, has been erected at Mr. Webster's expense at the South

1. From *Engineering*, London.

Metropolitan outfall at Crossness, and for more than twelve months trials have been conducted there on a scale corresponding to the requirements of a fair-sized town. These trials have certainly demonstrated the efficacy of the process, and, so far as their size and intermittent character would permit, they have shown it to be economical. The method followed is to electrolyze the sewage between

THE ELECTRICAL TREATMENT OF SEWAGE.—ANALYSIS OF EXPERIMENTS, 1888–9. PARTS PER 100,000.

—	APPEARANCE.	Odor.	Nitrogen as		Chlorine as chlorides.	Oxygen required to oxidize organic matter.	Suspended matters.		
			Free ammonia.	Albumenoid matter.			Total.	Mineral.	Organic.
..	Raw sewage, very turbid and opalescent	Bad	3.57	0.6	14.61	4.03	14.52	5.95	8.57
(A)	Effluent, clear	None	2.9	0.28	13.39	1.34	1.48	1.05	0.43
	Raw sewage, very turbid and opalescent	Very bad	1.89	0.54	29.5	2.57	15.48	7.43	8.00
(A)	Effluent, clear	None	1.8	0.24	29.0	1.21	2.20	1.91	0.29
Average of 20 analyses	Raw sewage, very turbid and opalescent	Slight	4.84	0.5	21.64	1.24	33.35	not estimated	
	Effluent, clear	None	8.22	0.2	18.62	0.52	1.56	"	

(A) Time of settlement, one hour in open reservoirs.

iron electrodes. The chemical reactions have not yet been very clearly ascertained, but the nascent chlorine and the oxygen are carried to the positive electrode, probably in the form of hypochlorous acid, the strongest disinfectant known, and there they rapidly oxidize the organic matter. The iron is also dissolved as a hypochlorite, and combining with the suspended matter, coagulates it in flocculent particles. These are buoyed up by the hydrogen bubbles, and rise to the top as froth, leaving clear liquid beneath. If the treated sewage be run into a tank and allowed to remain there for two hours, the hydrogen gradually disengages itself, whereupon the coagulated particles subside to the bottom as sludge, and the liquid can be run off. It is found on analysis that the amount of iron dissolved is equal to two grains per gallon treated. The matter in suspension, as shown by the above table, is nearly all removed, while the free ammonia and albumenoid matter are very sensibly reduced. Any one may try the experiment for himself in a beaker glass with a sample of sewage, and a pair of iron electrodes having a difference of potential of $2\frac{1}{2}$ volts; in a very few minutes the organic matter is rendered flocculent, and an hour sees it precipitated.

At Mr. Webster's works the raw sewage, as it is received from London, is lifted into a tank, from which it flows through a long inclined channel to a settling reservoir. In this channel there are a large number of iron plates arranged in groups. All the plates in each group are parallel to each other and to the sides of the channel, the sewage flowing between them in streams about an inch wide and the depth of the channel. The plates are alternately positive and negative, the difference of potential being $2\frac{1}{2}$ volts. The dynamo delivers current at a pressure of 20 volts, and six groups of plates are arranged in series. The time a particle of sewage is occupied in passing through the entire length of the channel varies, according to the degree of its pollution, from two to ten minutes. It is estimated that on the average it requires .25 ampere hour of current for each gallon treated, the current density being one ampere per 11 square feet of electrode.

No positive estimates of cost have yet been made. The sole working expenses are for coal, iron, and labor; and it is calculated that these will amount to 13s. per million gallons of London sewage, if treated on a large scale. Interest and depreciation of plant have to be added to this, and all the labor of dealing with the sludge. According to the Metropolitan Board of Works, it costs 6d. per ton to discharge this into the sea and about 1s. 6d. per ton to press it. In a town of 333,000, having a sewage discharge of 30 gallons per head, the mechanical power required is estimated at 264 h. p. and the expenditure of iron at 464 tons per annum. This latter is in the form of plates, one inch thick, run directly from the blast furnace.

There is a charming simplicity about Mr. Webster's process. He manufactures his chemicals to a great extent out of the sewage itself, and he uses them in the nascent state when it is well known they are most powerful. Instead of adding 5, 10, 12, or 15 grains per gallon of solid matter, as is now done, he only adds two, and he not only precipitates the matters in suspension, but he also removes some of the organic matter in solution. This latter is an important matter, as it defers the second decomposition so long that the effluent may be carried down to the sea, or oxidized by natural influences, before it can occur. The extent to which the purification can be carried is merely a matter of time, and in hot weather, when the quantity of sewage is reduced, and is consequently fouler, it can be allowed to remain for a longer period in the electrolytic bath.

ALTERNATE CURRENT WORKING.[1]

BY W. M. MORDEY.

I WISH to state at the commencement that this paper is not intended as a contribution to the comparison of the relative merits of alternate current working and of any system of direct current supply. The discussion of this question has already taken place, and those who took the A.C. side have no reason to be dissatisfied with the result. It may, however, be pointed out that exclusive advocacy of any one particular method of working, as being the best for all purposes, is not a position that is likely to be taken by any electrical engineer who has any extensive acquaintance with the various requirements and conditions that are met with in practice.

1. A paper read before the Institution of Electrical Engineers, London, May 23d, 1889.

WORKING ALTERNATORS PARALLEL, AND BEST PRINCIPLES OF CONSTRUCTION FOR ALTERNATORS.

This is a matter of very great scientific interest, and of still greater practical importance. It is not too much to say that the complete success of the transformer system of supply depends to a great extent upon whether alternators can be quite easily and successfully worked parallel. This has been strongly insisted upon, especially by the opponents of that system. The importance attached to it arises partly from the fact that the most economical method of supply is that of using always the smallest plant that will do the work, and increasing or decreasing the number of generating units in operation, according to the fluctuations of the demand. To do this most conveniently, the alternators should be worked parallel, and ought to be capable of being put in and out of circuit easily, and without causing even a momentary flicker or interruption of the light. The use of a large machine and engine for the small day supply is especially to be avoided. In almost all cases it is desirable to have a comparatively small set of plant for this work, even where large machines are used for the heavy evening work.

Another argument in favor of parallel working, as against the use of very large machines, is that it reduces the cost of the spare plant. Thus, if a station is provided with one or two machines and engines for the full load, the spare plant is equal in cost to the working plant, or perhaps to one-half as much. If, however, smaller generating units are employed, one set in four may be considered a safe allowance.

The history of parallel working of alternators may be briefly sketched.

In 1868 Wilde described parallel working and synchronous action of generators, and so nearly obtained synchronous motor action that it is extraordinary he should have missed it.[2]

In 1882–3 Dr. Hopkinson,[3] not knowing of Wilde's work, arrived theoretically at the conclusion that it was possible to work alternators parallel, but not in series, and subsequently demonstrated the fact by trials made, in conjunction with Professor Adams, on the De Meritens machines at the South Foreland lighthouse, which were run parallel and as motors. This was all laid before this society at the time, and was very fully discussed.[4]

In the course of this discussion in 1884, Mr. Alexander Siemens described some experiments showing that the Siemens alternate current machine ran as a motor.[5] This is interesting, as being, so far as I know, the only recorded instance of an alternator without iron in the armature being run as a motor. It will be remembered that the Wilde and De Meritens machines had iron cores. These experiments of Mr. Siemens were not very successful, the motor frequently stopping suddenly, even when doing very little work; but they were of value for comparative purposes.

Passing over the next few years, we find that the use of alternators had become of great importance on account of the growth and development of the transformer method of distribution, and that there was, and is, a certain amount of doubt and hesitation about working parallel. It is recognized that it has been, and can be accomplished, but that the arrangement is not one to be thoroughly and completely depended upon in every case. And there is sufficient justification for this doubtfulness. The present opinion may be fairly stated as follows:—Alternators may be successfully run in parallel if they have a good deal of self-induction, and to secure this it is better that they should have iron cored armatures.

In his recent paper on "Alternate Current Machinery," before the Institute of Civil Engineers,[6] Mr. Kapp dealt at considerable length with this part of the subject, and his views, I need not say, may be accepted as quite correctly representing the current state of knowledge and opinion. Referring to alternators that have self-induction negligible, Mr. Kapp says:—"Machines of this type can only be run in parallel if the strength of their field is adjusted with almost mathematical precision, and as this would require more skill and attention than is available with the ordinary staff of a central station, such machines are practically unfit for parallel working. To make them fit for this method of working, either the armature resistance or the self-induction must be increased. An increase of resistance in order to be effective would have to be so considerable as to seriously prejudice the electrical efficiency of the machine, and this expedient may, therefore, be dismissed as impracticable. The other plan of increasing the self-induction is not open to the same objection. It has the effect of lowering the plant efficiency, but its influence upon the electrical efficiency is only indirect, and so small that it may be neglected. From the foregoing, it will be readily seen that the only and sufficient condition for successful parallel working is a sensible amount of self-induction in the armature circuit. If the armature itself does not possess the quality in a sufficient degree, a choking coil of suitable self-induction must be inserted into the circuit of each machine. The results here arrived at, by a mere theoretical investigation, are entirely borne out in practice. It is well known that alternators having no iron in their armatures cannot be run in parallel, except by the adoption of some such expedient as choking coils; also that parallel running is feasible with those alternators which have iron-cored armatures, and then with different degrees of security."

Now, this is a very serious state of affairs, for it really means, if true, that the only machines suitable for central station supply are those that, on account of their high self-induction and resistance, are bad regulators that will not bear any considerable change of load without varying a good deal in E. M. F., and that are wasteful on open circuit.

For my part, I have seen enough of the use of iron in armatures to wish to do without it if I can, and I have repeatedly pointed out that, if iron is really necessary, the armature is the very worst place to put it. For the purpose of increasing the self-induction it can be much better used outside of the machine, and put in some place where it is not subject to all the losses, restrictions, and disadvantages that necessarily accompany its employment in the core of an armature. If it is not in the armature it can be entirely removed when not required for the purpose for which it is thought to be necessary—that is, when only one machine is in use. To put iron in an armature merely to increase self-induction appears to show a want of common ingenuity and an absence of the sense of proportion.

But let us examine the evidence on this matter, in order to see what basis of fact there is for the present views.

In the first place, it will be found that the use of iron armatures is not in all cases to be relied on to give successful parallel working. In the discussion last year, Mr. Gordon, who has had very considerable experience, and who used iron largely in his machine, warned us in strong terms against working in parallel. He said:[7] "We know that experiments have been made by coupling a number of small alternate-current machines together, and at the South Foreland they were successful, but that was because they were working on arc lamps." A little elucidation, perhaps, is necessary here: "Many of us have tried them, and they will, on trial, work together, no doubt, but they do not work together till they have run for three or four minutes; they will in that time jump, and that jumping will take months of life out of the 40,000 lamps. That alone is rather a serious difficulty in coupling machines together, and I think we may take it in practice—I am not speaking about the laboratory or experiments—we do not couple machines."

The Zipernowski alternator will, however, work parallel, but apparently not very well; to get it to do so the periodicity has had to be reduced to 42, as we now know.[8]

Further, I have recently seen a communication from the highly experienced makers of a well-known alternator in which iron is used, stating that, if it is desired to run in parallel, the machines, engines and arrangements must be in every way identical: the impression conveyed being that with this machine the greatest care is necessary to ensure a successful result.

Then, again, the large experience of the Westinghouse company in the United States has shown that their iron-cored alternators will work in parallel under some conditions. We are told that, with these machines, "parallel coupling always succeeds when they are loaded to about half their maximum output or over, but that machines working under a less load cannot with certainty be so coupled."

But the other day Professor Forbes described[9] successful parallel working with the iron-cored Lowrie-Parker alternators at West Brompton, even with very light loads.

Thus it will be seen that we have evidence ranging from complete failure to complete success with iron-cored machines.

It is proved, then, that the presence of iron is not alone sufficient to ensure success, for the use of iron is associated equally with failure and with success.

That the success attained is complete only as regards the fact of synchronism, is shown by the following extract from Professor Forbes's remarks in the discussion on Mr. Kapp's paper, which I quote at some length, because Professor Forbes has taken every opportunity of ascertaining, by personal observation, what is being done, and because he gives us what is alone of much service at the present stage, viz., the independent record of actual facts, and tells us clearly what the real difficulties are.

The passage is[10]:—

"The question of parallel working was one which had been very much discussed as to whether it was desirable or possible. * * * It was always possible, as Mr. Kapp said, with machines which had a very high self-induction—machines in which the armature had a great mass of iron in it. At the same time, the introduction of that self-induction into a machine reduced what Mr. Kapp called the plant efficiency of the dynamo machine; and if they could work out, as he believed engineers would work out, some better means of making machines work in parallel, it

2. "On a Property of the Magneto-electric Current to control and render Synchronous the Rotations of the Armatures of a number of Electro-magnetic Induction Machines."—H. Wilde, *Phil. Mag.*, January, 1869, pp. 54-62.
3. *Proc. Inst. C. E.*, 1882–3.
4. *Journal*, xiii. (1884), pp. 496–559.
5. *Journal*, xiii., p. 525.
6. *Proc. Inst. C. E.*, February, 1889.
7. *Journal*, xvii., pp. 195–6, February, 1888.
8. See under "Periodicity."
9. Board of Trade enquiry. April, 1889.
10. *Proc. Inst., C. E.*, February 19, 1889.

would be very desirable. Another reason why the heavy self-induction was injurious, was that it required such continued attention on the part of those in the station to see that the pressure was maintained constant. The electrical pressure varied so much, that the quantity of current being developed, as shown by the table of curves, was seriously affected, and constant attention was required to keep such a machine regulated to the right pressure; whereas a machine which had no self-induction, or very little, gave off the same electric pressure, or nearly so, whatever the current might be, so long as the speed was maintained constant. As to the possibility of working conveniently in parallel with those machines, he might say that the experience of America had been completely against it. It was there found that it was possible to work in parallel, but that it enormously increased the amount of skilled attention required in a central station."

This is a very strong condemnation of the present system of obtaining synchronism, and at the end of his "Central Stations" paper[11] Professor Forbes returns to the subject in these words:—

"I venture to think, however, that the plan now universally proposed for making machines work in parallel will not long be tolerated. This is to introduce into the machine a large amount of injurious self-induction, thus diminishing the plant efficiency, and rendering the equalizing of pressure with various loads very difficult."

Turning now from alternators with, to those without iron-cored armatures, we are brought face to face with the serious fact that, in spite of the many inconveniencies connected with the use of very large machines, Mr. Ferranti is laying down the Deptford station to work with engines and alternators, each of several thousands of horse-power, and is depending upon the employment of spare engines and machines, of corresponding size, to prevent or to minimize the risk of wholesale extinction of the lights. It is understood that one of the principal reasons for doing this is that parallel working is not to be relied on.

The next question is, is it clear that, in order to be able to run them parallel, or as synchronizing motors (for I need not say that the two qualities are inseparable and are in fact identical), alternators should be bad regulators, should have large self-induction, or high resistance, or both? I think not. I have mentioned Mr. Gordon's machines, which certainly had the first of those qualities, but they would not run parallel. Other machines that I have referred to, and whose parallel working is not to be depended upon, are at any rate not remarkable for absence of self-induction.

Again, is the absence of iron from the armature cores alone sufficient to deprive a machine of self-induction, and to give it a straight characteristic? I think not; for I have tested machines that had no iron, but that had a good deal of resistance, very considerable self-induction, that had very crooked characteristics, and yet that would not run parallel under any circumstances whatever.

So we see that neither a bent characteristic, nor self-induction, nor resistance, nor the use of iron cores, nor even the simultaneous possession of the whole of these admirable features and qualities—that none of these things is the secret of successful parallel working.

Perhaps—and this is a dreadful reflection—it is the exact opposite of all these.

Now I am in the unenviable position of being out of accord with the theories, the practice, the principles, and the explanations of the very able men who have lately written, spoken, and worked on this subject. I have no doubt that all they have said is perfectly correct, so far as their difficulties are concerned,—that they have experienced considerable trouble in working parallel, and have even in some cases met with actual failure. But this was partly because they have been unfortunate or unwise in the apparatus they have used, and partly because the principles that have been relied on to ensure success have not been in all respects suited to the case.

Although the conditions of the two problems are not in all points similar, I very respectfully submit that we are in danger of repeating the old mistake that was made regarding direct current motors. We were taught that self-induction in the armatures was good, and that a special form and special proportions should be given to such motors; and I was very unorthodox when, in 1886,[12] I asserted that self-induction was not a virtue to be cultivated in motors any more than in dynamos, and, generally, that a good motor was a good dynamo, and *vice versa*. However, it is some satisfaction to know that the views I then expressed have received the sanction of general practice, although I am afraid that in the eyes of Professor Ayrton and Perry those views remain as unorthodox as ever.

Now, I am prepared to take a precisely similar stand with regard to alternators, and to submit for your criticism the view that a perfect alternator for any and every purpose should have no resistance and no self-induction.

I prefer to regard the question of alternate current parallel working as a question very largely depending upon what are the best principles of construction for synchronizing alternate current motors. It is very much better and simpler to look at it from this point of view than from any other, and I venture to assert, in spite of all that has been said to the contrary, that if alternators are made, amongst other things, with the least possible self-induction and the lowest practicable resistance, they will not only be the best alternators, but they will best run parallel, and will do so because they will then be the best synchronizing motors.

I think that even the advocates of large self-induction will admit that that quality does not improve an alternator *per se*, they only introduce and tolerate it on account of its supposed bearing on parallel working (I could quote a number of such admissions), but it appears to me that, properly regarded, self-induction is not even a necessary evil, it is an unmitigated evil. It is an evil even for this narrow and restricted purpose.

What does it do? When machines are getting out of phase, it steps in and prevents that ready transfer of current which is required in order to check the leading machine and to accelerate the lagging machine. It prevents the latter from immediately and unhesitatingly developing those motor properties which lie at the root of successful synchronism. The foundation of parallel working should be that the prime motors are under the control of the generators. The question turns, therefore, partly on the qualities of the prime motor, but much more largely on the motor qualities of the alternators.

I am prepared to admit that if the tendency of the prime motor to lead or to lag is so great that under no circumstances can it be controlled—and this may arise either from excessive power on the part of a prime motor, or from defect of motor power in an alternator—then large self-induction or resistance may be of use in order to prevent one or more of the machines being burnt up, not, however, as useful and not as effective as a safety fuse; but self-induction under such circumstances is not an assistance to parallel working—quite the contrary. If it were absent, probably the machines would run parallel all right. They would be much less likely to be burnt up without self-induction than with it. Self-induction is useful because it prevents the machine which ought not to have it from being burnt up because it has it.

(*To be continued.*)

11. *Journal* xviii., p. 195.
12. *Phil. Mag.*, January, 1886, "The Dynamo as a Generator and as a Motor."

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Mayor's Change of Heart.—The Pole-Choppers.—Tests of Cables in the Subways.—The Governor Signs a Bill Giving the Power to Surface Street Car Lines to Change Their Motive Power.—Opposition to the Center-Bearing Rail.—A Writ of Habeas Corpus Asked For to Prevent the Execution of Kemmler.—One of the "Electric Sugar" Gang Sentenced.—Fire at the Brush Station.—The Electric Light for the Metropolitan Museum of Art.—The Hell Gate Tower Removed.—A Street Car Driver Receives a Thousand Volt Alternating Current; His Sensations Described.—Rhode Island Notes.

MAYOR GRANT has receded, with much grace, from the position which he had maintained in respect to stringing wires in streets unprovided with subways, and permits are now issued by the board of electrical control for the erection of poles and wires, conditional, however, upon each company agreeing to place all its wires in subways when same are built. In the meantime the pole-choppers have visited the vicinity of the Stock Exchange; but the capacity of the subways thereabouts is entirely inadequate to contain the enormous number of wires now in the air, and very little change has been made, therefore, in the appearance of the down-town streets.

Dr. Wheeler, the expert of the board, has recently completed a series of tests of cables carrying the arc light circuits of the Brush and United States companies, and other cables carrying the alternating currents. The tests extended over a period of fifteen days, and a very satisfactory showing was made. The results obtained, however, are hardly conclusive, the questions of durability and cost not yet being solved satisfactory. Cables made by the Bishop Gutta Percha Co., the Standard Underground Cable Co., and others, were used.

The governor of the state has signed the Walker bill, which removes the legal obstacles in the way of the surface street car lines changing their motive power to cable or electricity. It is surprising how quiet such an important measure was kept during its progress, the newspapers making no mention of it.

The Third avenue company has long been fighting the city in the courts in an endeavor to remove the legal obstacles which prevented the cabling of their main line, that company also

owning the One Hundred and Twenty-fifth street cable road. President Hart, of that company, claims to have made an exhaustive study of the different electrical systems, and does not believe that any of them are suited to the conditions of his traffic. "The overhead system," he states, "is simply out of the question in New York, and the storage battery as yet not adapted to roads with a heavy patronage; and, while it is stated that the trouble with the conduit system in Boston was exaggerated, and that it failed because the advocates of the overhead system wanted it to fail, we are not prepared to undertake any experiments."

The objection of Mayor Grant against the center-bearing rail is as pronounced as that of Mayor Hewitt; and in a letter to the corporation counsel he states that "there exists a well-settled conviction in the public mind that the form of rail laid in our streets is little short of a public nuisance," and he desires to know under what rights these rails are laid, with the object of abating the nuisance.

The arguments for a writ of habeas corpus to prevent the execution by electricity of Kemmler, who was the first criminal sentenced under the electrical law, will be heard shortly in Buffalo. Ex-congressman W. Bourke Cochran has been retained by the plaintiffs, and he expects to be able to convince the court of the propriety of appointing a commission to take testimony as to the probable result of using electricity to produce death, on the ground that it is a "cruel and unusual" punishment.

The trial of Rev. W. E. Howard, of electric sugar notoriety, has resulted in a conviction, and he has been sentenced to nine years and eight months in the penitentiary.

The Elizabeth street station of the Brush Electric Light Co. was set on fire June 18 by crossed wires, and damaged to the amount of $5,000. The switch-board was rendered entirely useless, and service temporarily interrupted.

The Metropolitan Museum of Art, in Central Park, is to have its own electric light plant of a capacity for twenty-eight hundred incandescent lamps.

The electric tower at Hell Gate, constructed by the government at an expense of $20,000, has been removed. It is well-known that the pilots have always complained that the electric lights blind their eyes, the light being so intense as to prevent objects outside of its rays being discerned, and thus they find difficulty in finding the channel. On the other hand, others claim that the light enables boats to proceed without a pilot's assistance; but even if such is the case, the pilots have succeeded in keeping the electric lights off the rivers and harbors.

A Grand street car driver had an opportunity of trying the effect of a 1,000-volt alternating current on June 16th, from a wire of the Manhattan Electric Light Co.

"A Second avenue car, which was ahead of mine," said Miller, "struck the wire. The driver raised the wire so as to clear his car. The strain caused the wire to sag more, and as my horses could not pass under it, I went ahead with the car-hook. I twisted the hook in the wire and gave it two or three jerks, when the current struck me and I lost my senses. My fingers are badly blistered, the muscles in my arms and legs are sore, and there are some bruises on my hand where it struck the pavement when I was rescued, but otherwise I feel all right. If I were going to be executed, I should choose a rope in preference to electricity."

The car company's starter offered him a light car until he fully recovers, which he accepted and went to work.

"The wire carried a 1,000-volt alternating current," said Superintendent McGrath, of the Manhattan company. "I am not surprised at Miller's escape, as I never heard of an alternating electric light current killing a man, and I doubt if Harold P. Brown can point to an authentic instance. We do not claim that it would not if generated in sufficient quantities, but I know of no dynamo that is used for electric lighting that can generate a current of over 1,000 volts, and there are scores of instances on record of men who have withstood that amount of alternating current."

"I have no doubt," said an electrical engineer, who has no connection with any electric light company, "that if allowed to proceed, Harold P. Brown will manage to execute Kemmler, but that he will do it humanely I do doubt, because he has not the capacity to make proper experiments in that direction; and, even if he had, he has not devoted enough time to the work. I would want months to qualify myself to make such recommendations as Brown made, and the ridiculous suggestions he made show that he has not mastered the subject. In fact, it is apparent that Brown merely sought to injure an electric light company for personal gain, and not to honestly enlighten the authorities. Under the new law he has a week to do it, and he can easily torture him to death in that time. Neither Harold P. Brown nor any other living man can tell just how much alternating current will kill without mutilating."

Aristocratic Newport is terribly agitated over the proposed electric railway, and a petition for an injunction has been filed in the Supreme Court of Rhode Island.

Word comes from Providence that negotiations are under way for equipping the entire surface street car system with storage batteries of the Julièn type.

NEW YORK, June 22, 1889.

PHILADELPHIA.

The Pennsylvania Globe Gas Light Co. Makes a Vigorous Incursion Into the Electric Lighting Field.—A Suit by the Receiver of the American Rapid Telegraph Co.—Underground Wire Matters.

THE Pennsylvania Globe Gas Light Co. is expanding the scope of its usefulness, and bids fair to be a formidable rival among electric lighting companies. It has arranged to control the Thomson-Houston system of electric lighting in Manchester, N. H., and Wilmington, Del. The Globe company has been lighting the suburbs of cities with gasoline lamps, but very often a cry comes up from suburban residents for something better, and in this way the Globe company felt that it was in danger of being crowded out by the competition from electric lighting companies. In order to hold its own the Globe determined in some cases to put in two bids, one for lighting by gasoline, and a second by electricity, and it made arrangements with the Thomson-Houston company to control its system for the purpose.

Manchester, N. H., was the first place where the new arrangement was applied. In that town 500 arc lights of 2,000 candle power and 4,000 incandescent lights are now in use supplied by the Globe company.

The present contract of the Globe company for lighting Wilmington with gasoline expires in a short time, and it will submit two propositions for lighting hereafter, one by gasoline and another by electricity.

The towns of Lewes, Dover, Newark, Milford, New Castle and Wilmington, Del., are being negotiated with for electric lighting. The Globe has contracts for gas and gasoline lighting at Reading, Pittsburgh, and Ardmore, Pa., and in this city, and when the contracts expire it will make a fight for electric light contracts if there is a demand for improved lighting.

Colonel Robert G. Ingersoll, of New York, and John Hampton Barnes, of this city, representing the United Lines Telegraph Co. and the Postal Telegraph and Cable Co., have filed an answer in the United States Circuit Court to the suit to recover $60,000 rental for the use of telegraph wires, brought by Edward Harland, the receiver of the American Rapid Telegraph Co. The answer reviews at length the circumstances of the controversy, which grows out of the joint use of a number of wires by the American Rapid and Bankers' and Merchants' companies which had been strung on each other's poles. The dispute is likely to be the subject-matter of future argument.

At a meeting of council's electrical committee recently an ordinance, authorizing the board of highway supervisors to designate the location of electrical conduits in the streets, was referred to a sub-committee consisting of Messrs. McMurray, Patton and Abrams. Mr. Patton opposed the bill on the ground that it conferred upon a body created by them power properly belonging to councils. Mr. Abrams said that the bill was intended to enable a company laying conduits to pass from one side of a street to another when impeded by another plant.

An ordinance providing for the construction of subways by the director of public works, into which the companies should put wires and pay an annual rental to the city, was referred back to councils with a request to send it to the finance committee, as there is no appropriation for the purpose.

PHILADELPHIA, June 18, 1889.

BOSTON.

Electrical Legislation.—Electric Railway Notes.—Progress of the West End Railway Company.—Failure of the Conduit on Boylston Street.—The Stationary Motor Business of the Thomson-Houston Company to be Conducted by a Separate Organization.—The Erie Telephone Co.

THE "Great and General Court" of Massachusetts adjourned June 8th. Among the new enactments were bills permitting the extension of the capital stock of the American Bell Telephone Co. from $10,000,000 to $20,000,000; for the regulation and removal of posts, wires, and other structures in or under public ways and places; and relating to transmission of intelligence by telephone. Among the defeated measures were the schemes for electric elevated roads; taxation of telegraph companies on the basis of miles of wire instead of miles of line; extending the powers of the gas commissioners over electric light wires; execution of the death penalty by electricity; authorizing the town of Danvers to provide its people with electric light and power; and regulating telephone rates.

The Newton aldermen have granted permission to the Newton Street Railway Co. to use the single trolley overhead electric system to propel its cars from West Newton to Newton, to connect with the West End road at Watertown. The company must have its tracks laid within six months, use iron poles twenty feet high, and give a bond of $10,000 to insure the city against damages to its fire-alarm signals, etc.

It is announced that the first through line to be equipped with the overhead electric system by the West End Street Railway will be from Cornhill to Franklin Park, via Tremont street, Shawmut

avenue and Warren street. The Hampden street and Blue Hill avenue line will next be equipped. It is proposed to rebuild the entire double track on Tremont street from Cornhill to Shawmut avenue, and thence on Shawmut avenue, Roxbury street, Guild row, Dudley and Warren streets. Also, the single track on Cornhill, Washington and Boylston streets, going south; the double track on Blue Hill avenue, Hampden and Northampton streets, and to build a new piece of single track through Ruggles street from Washington street to Shawmut avenue.

President Whitney says that the poles for the West End Railway Co.'s electric railway to Franklin Park have been received, and the work of putting them in place on Shawmut avenue and Warren street will begin in a few days. It has not yet been decided where the power-house for this section will be located.

It is understood that the directors of the West End Street Railway have decided in favor of the Thomson-Houston system, provided satisfactory terms can be made with that company. About the only difference is one of money, the West End's offer being considerably less than the Thomson-Houston company desires. Conferences have been held, and it is thought probable that in the course of a few days a satisfactory agreement will be reached.

On the 11th inst. the attempt to run electric cars through Boylston street was given up until the conduit is replaced by overhead wires. The test of the conduit has proved its utter unreliability, and for a week or more all the electric cars had been hauled between the entrance to the Back Bay Park and Park square by horses. It takes four horses to draw each electric car, and for the present the common horse cars will be run over the line where the conduit is laid.

As there have been some misapprehensions concerning the formation of the new motor company by Thomson-Houston interests, the impression having been given by some accounts that the new company will include the railway business, a correct statement of the facts is furnished by the Thomson-Houston company in substance as follows: The stationary motor department of the Thomson-Houston company has grown so rapidly that it is thought advisable to put it in charge of a separate company, organized with $1,000,000 capital, nearly all of which will be held in the treasury of the Thomson-Houston company. This motor company will take only business of stationary motors for ordinary commercial and mining purposes, leaving all the railway business with the parent company, as heretofore. About fifty important railway contracts already have been secured by the Thomson-Houston company, aggregating between $1,000,000 and $2,000,000.

Although it often has been explained, the exact status of the Erie Telephone Co. is not generally understood. Its sole function is that of a stockholder. It holds no license from the American Bell. Originally it owned all of the stock of the Northwestern company, operating in Minnesota; all of the stock of the Cleveland company, operating in Cleveland; and all of the stock of the Southwestern company, operating in Texas and Arkansas. Each of these companies had temporary licenses from the American Bell Co. That of the Northwestern company expired in 1887. That of the Cleveland company will expire next October, and that of the Southwestern company will expire in June, 1891. When the Northwestern company's contract expired, *it*—not the Erie company—had to purchase a new one, and for this it paid 30 per cent. of its stock to the American Bell. From that time the American Bell and the Erie were joint owners of the stock of the Northwestern company, the latter owning seven-tenths and the former three-tenths. When the license under which the Cleveland company operates terminates in October next, that company, *not the Erie company*, must make the best terms it can with the Bell company and buy a new license. It must make over *at least* 30 per cent. of its stock to the Bell, so that the Erie, instead of owning all the Cleveland stock, will own at most seven-tenths. And the same will be true of the Southwestern company in 1891. When *all* of the stock of all three companies belonged to the Erie, that stock ownership carried with it the ownership of all the property of all three companies. Hence it was a harmless fiction for the Erie company, in its annual statements, to combine the assets of these three companies and call them *its* (the Erie's) assets. In the Erie's annual statement, issued in March, 1887, "Plant" appears as an Erie asset to the amount of $2,350,000, this being the aggregate value of the "plants" belonging to the three companies, and, consequently, through its stock ownership, belonging to the Erie company. But later in that year the Erie company ceased to be the sole owner of the stock of the Northwestern company, and became the owner of only seven-tenths of that stock, and consequently of only seven-tenths of the property of the Northwestern company One of the items of that property was the Northwestern company's plant, which, combined with the plants of the Cleveland and the Southwestern companies, made up the $2,350,000. But in the statement of March 31, 1888, and again in that rendered March 31, 1889, the plant still appears at the same figure—$2,350,000; from which one would reasonably infer that the Erie owned (through its stock ownership) just as much "plant" as before, but such does not seem to be the fact from this brief analysis of the relations between the company and its sub-companies.

The annual meeting of the stockholders of the Erie Telegraph and Telephone Co. was held at the Hotel Normandie, New York, on the 11th inst. A board of directors was elected, as follows: Messrs. Levi Sprague, Charles J. Glidden, Charles E. Adams, Francis Jewett, A. C. Russell, J. W. C. Pickering, Abner S. Adams, of Lowell, Mass.; Wesley A. Gove, of East Boston; James A. Weston, of Manchester, N. H.; H. A. Whiting, of Wilton, N. H.; and W. J. McKinnie, of Cleveland, O.

There has been some antagonism in the management of Erie's affairs, and the retirement of Mr. Bennett, first from the presidency, and now from the board of directors, undoubtedly was make for harmony in the company's management. There are intimations that the matter does not end here, however, and hints of possible continuation of questions at issue in the courts have been heard.

On the 12th inst. some weakness was caused in Bell Telephone stock by the unwarranted publication on the street of a report that the Bell Telephone Co.'s extra dividend might be 2 per cent. less than last year. The stock declined from 242½ to 240, but fully recovered when the dividend was announced as had been expected—3 per cent. regular and 6 per cent. extra, payable July 15, to stockholders of record June 29. The directors voted to recommend the issue of $1,125,000 new stock in October, and the same amount in April, 1890—a total of $2,500,000—and a special meeting will be held in September to ratify this action.

BOSTON, June 17, 1889.

CHICAGO.

The Proposed University at Chicago; a Desire to Include a Scientific School on Mr. Rockefeller's Foundation.—Western Opinions on Electrical Executions.—The Execution of Criminals as a Business Venture.—Professor Barrett Studying Electric Lighting Plants in the East.—The Chicago City Lighting.—The Illinois Legislature.—No Telephone Bill Passed.—The General Street Railway Bill, Permitting Cable or Electric Traction Without Local Consent, Vetoed by the Governor.—The Chicago Arc Light and Power Co.; Their First Alternating Current Plant Installed.—Changes in the Chicago Electric Club.—Affairs of the Defunct Great Western Telegraph Co.—The Auditorium Electric Plant.—Electric Light Notes.

JOHN D. ROCKEFELLER's gift of $600,000 for the establishment of a University in Chicago, on condition that the Baptists of the west raise $400,000 for the same purpose, has been widely commented upon. While the first object is to establish a college of liberal arts, there is a very strong desire among persons interested in the movement to secure the endowment of a scientific school at the same time. There is beyond a question a need of such a school in Chicago. In a number of instances inquiries have been addressed to the correspondent of THE ELECTRICAL ENGINEER by persons who wished to pursue a course in electrical engineering. There has been no school of the kind here, and many a promising young man has for that reason been obliged to give up all ideas of study in this department, or to content himself with an apprenticeship in a factory. The Baptists have not yet been able to secure the money necessary to make Mr. Rockefeller's pledge good, but it is thought they will secure the amount without much difficulty. The Chicago Manual Training School has done something in the field of electrical instruction, but the work has been confined to the instruction of boys. At the recent exhibition of work done by the pupils, several small dynamos and motors were shown.

Electricians of Chicago are not, as a rule, favorable to the infliction of capital punishment by the application of electricity as proposed in New York. They do not differ much, probably, in that respect from their brethren scattered throughout the country. From the opinions which have been expressed casually in the hearing of the correspondent of THE ELECTRICAL ENGINEER, it may be inferred that their objections to the "electrical route" —to employ a newspaper phrase—are not based so much on the disfavor which will accrue to the mysterious force as on the curious methods employed in arranging for the executions. Western electricians are rather of a utilitarian cast, and they have, as a rule, no sentimental objections to the use of electricity as a death-dealing agent. It may indicate more clearly the position which a number of these gentlemen assume, to quote the views of one of them. "I don't like this business of executing criminals by electricity as it is proposed in New York. Prove to me that it can be done satisfactorily and I don't object. But for heaven's sake, don't make the selection of apparatus an advertisement for one company and a stab to another. To read the stuff that is sent from New York is enough to disgust every one. Has the idea of the legislature in adopting the new method of inflicting the penalty been to boom one company or hurt another? Let persons who have no direct interest in the several systems, make arrangements for executions. The whole subject is ghastly. I declare, if an execution ever does take place we may expect to see boys standing about the prison distributing dodgers telling us that the dynamos which have just caused death were of a certain

make. The electrical method may be the best means of execution; if so, let us have it, but don't give us horror and farce comedy mixed up for our delectation. If necessary, let the state have a special dynamo made. Continuous or alternating, it will do its work fast enough."

The secretary of state of Illinois, issued articles of incorporation to a company last week whose purpose it is to assist sheriffs to execute the death penalty. The corporation is to be known as the American Executing Co. of Chicago. The three gentlemen who compose the company propose to hire executioners. When a sheriff is too squeamish to do his duty these hirelings will pull the lever or turn the switch. It seems scarcely credible that a company could be formed for this purpose, and it was at first assumed that the corporation existed only in the mind of a sensational reporter. But a joke it is not. The company is regularly organized, and the incorporators assert their belief that they "have a good thing." The organization came into life, it is believed, as a result of the tendency in legislatures in several states to execute capital sentences by the application of electricity. The company propose to keep on hand electrical apparatus, to be shipped wherever it may be required.

Professor J. P. Barrett, city electrician of Chicago, has been making a trip through the east to look at improvements which will make more perfect the equipment of the new city electric light stations to be built. Several contracts for the new work have already been let. For several weeks during the spring and early summer Chicago experienced a large number of heavy rain storms, and considerable interest has been felt in the test of the underground system by the continuous storms. Professor Barrett reported that he had experienced no trouble whatever. The great advocate of underground wires considered that the satisfactory working of his underground mains during the weeks of unusually rainy weather constituted a complete vindication of his views, which many arc light gentlemen are inclined to believe are, to say the least, slightly radical. The telephone company suffered considerably from the heavy rains, and was obliged to keep its forces of repairers on the keen jump for a week or more.

In almost every letter which was sent to THE ELECTRICAL ENGINEER from Chicago during the winter and spring, references were made to the several telephone bills before the Illinois legislature. That much-abused body has adjourned, and although a considerable part of its time was devoted to wrangling about telephone legislation no action was taken. One of the bills for the regulation of telephone rates came within an ace of passing, but in spite of persistent drumming up of representatives and an endless amount of newspaper comment the bill was effectually killed. Few persons will complain. Assuming that telephone rates are high in Chicago, that fact scarcely justifies the passage of a bill conceived in a spirit of acknowledged hostility to the telephone interests. Another bill of some interest to electrical companies did pass. The measure gave to all dummy and horse car companies the right to substitute an electric or cable system without securing consent of property owners or city councils. Probably few companies throughout Illinois, if any, are anticipating the adoption of a cable system, so that the measure was significant only in the case of those companies which are considering the adoption of electric motors. There went up from all quarters an angry protest against the bill, and the governor was besieged with remonstrances. He yielded to the allegations against the measure and vetoed the bill. He thought the public ought to have a voice in deciding by what means street cars should be propelled. The measure and its fall amounted to little. There is no doubt that city councils throughout Illinois, outside of Chicago, will grant franchises to companies desiring to change their motive power by the substitution of electric motors.

The Chicago Arc Light and Power Co. has purchased the plant of the King Electric Co., which was located on State street. It had a capacity of 85 arc lights. The Schuyler system has been used in the station. A. F. Bennett, the secretary and treasurer of the Arc Light and Power Co., recently resigned. C. H. Wilmerding, the present superintendent, was selected to fill the vacancy. He will continue to occupy the office of superintendent. The company has recently installed the first alternating dynamo ever operated in Chicago. It is a 1,000-light Thomson-Houston machine. It was installed to prevent West-side customers from purchasing private plants. All the circuits are underground. The copper core of each cable has a carrying capacity equal to a No. 6 wire. In order to test the different kinds of cable, and determine what is best suited for such work, various lengths of each make are spliced together and used as one. The cables are laid in the same manner, and in the same conduits as those for arc service. All converters have thus far been located within doors, and are securely boxed out of reach of any possible meddler. The lamps used are 52 volt 1.04 ampere. The lamps are rented on the contract system. No ground wire from the converters is used. The Arc Light and Power Co. prefers to run its system entirely insulated from the earth.

One can scarcely realize the changes which have occurred in the Chicago Electric Club during the last few weeks. The new club rooms have made the club a new organization. It is now liberally patronized by the members, who can be found there at all times of the day. The membership is increasing and after every dollar of its indebtedness is paid the club will have a handsome balance in the bank. It is now proposed to uniform the attendants. Such extravagance must seem odd to the members of the National Electric Light Association, who found the club last February quartered in the darkest and dingiest of quarters. On June 17, C. C. Haskins had the honor of presenting the first paper before the club. His subject was "The Babyhood of the Electric Telegraph." He reviewed at considerable length the efforts of scientists which culminated in the discovery of Morse.

The fight of the stockholders of the defunct Great Western Telegraph Co. against the receiver of the corporation has been referred to heretofore. After the collapse of the corporation the receiver attempted to collect from the stockholders 35 per cent. on the stock for which they had subscribed. Many resisted on the ground that they had been induced to subscribe by false representations. Judge Tuley has handed down a decision which in effect gives the luckless stockholders an opportunity to show why they ought not to pay the 35 per cent. indebtedness. The decision affects 2,000 stockholders, scattered all over the western states.

The work on the Auditorium electric light and power plant is progressing with rapidity. The building is almost entirely wired, and the installation of 10,000 lights will soon be ready. Leonard and Izard, the contractors, have just obtained an award of another large contract. They will furnish a 5,000-light incandescent plant for the factory of the Elgin Watch Co. at Elgin, Ill.

The train house of the Wisconsin Central Railroad Co. in Chicago, will be lighted by arc and incandescent lights. The building is 560 feet long by 120 feet in width. The plant to be installed will be one of the finest in the country if the purposes of the company are realized. The system has not yet been selected.

The old Libby Prison, which is to be put together in Chicago, is to be lighted by arc and incandescent lights. Grace Church, which adjoins the site selected for the famous prison, will probably be lighted by the plant in the latter building. If so, it will be the first electrically lighted church edifice in Chicago.

The electrical piano which amused the members of the New York Electric Club a few months ago, has been on exhibition in Chicago. It made quite a favorable impression.

The employés of the Western Electric Co. held their annual pic-nic June 15, and had a thoroughly enjoyable day.

CHICAGO, June 20, 1889.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall street, New York city.*

NOT A UNANIMOUS VOTE.

[109.]—Writers for the various electrical journals, though prone to disagree in their several conclusions on many topics, apparently make an exception in the case of their ideas as to the advisability of employing electricity for the execution of criminals sentenced to death. It seems to be the general opinion that the law-makers have rushed in where electricians have feared to tread, and that it is now the turn of the law to be condemned lest *it* may be executed.

Some of the reasons advanced are plausible enough, and doubtless will prove as satisfactory to many readers as they have done to the writers. But I am persuaded that one statement put forward by prominent electricians, seconded by others not less prominent, and carried far by the press, does not meet with the approval of all independent thinkers. This opinion is, substantially, that the adoption of electricity to enforce the death penalty will signify its coincident entrance into the region of disrepute.

If this view be correct, then were also accursed the hemp, because of its rope that strangles the strangler; the rifle, whose bullet sends the deserter to his final court-martial; the prison whip used to enforce to the sworn protector of woman the lesson that brutality should not begin at home.

With the utmost respect to the writers to whom I have referred, and with all admiration for their zeal for the honor of the profession, I desire to take my stand on entirely different ground; conversations with others who have not expressed themselves in print convince me that I shall not stand alone. I am of the opinion that electricity instead of suffering a debasement, will, on the contrary, be signally honored by its share in the enforcement of righteous laws. My only object at this time is to

protest against an idea which is, in my belief, wholly erroneous. If the law in question be unrighteous; if it be inexpedient, or if it partake of the nature of a retrograde movement, there will likely be a revision in the near future. On a recent trip by railway, a question suggested by an examination of some unused apparatus, elicited the information that a certain system of electric signaling, after sufficient trial, had been discarded for a return to the rope which had been found fairly efficient. If executions by electricity prove unadvisable, it may be assumed that they will, as well, soon be unlawful, and that the rope, with its burden, will again have full swing.

FRANK C. LOCKWOOD.

Malden, Mass, June 15, 1889.

A CORRECTION.

[110.]—In my communication on Electrical Energy and Light, in the June number, I inadvertently used the name of Professor Stone instead of that of Professor Osmond. You will confer a favor by correcting. J. W. MOORE.

Lafayette College, Easton, Pa., June 17, 1889.

CATALOGUES AND PAMPHLETS RECEIVED.

The Browne & Sharpe Mfg. Co., Providence, R. I., issue a descriptive circular on the Construction and Use of the Universal Hand Lathe made by them. They have sought to supply an "all around" hand lathe suitable for either bench or stand, the chief characteristic of which should be its *handiness*, its ready adaptation to a wide range of use. Such a lathe as is very fully described and illustrated in this circular is not only of great value in large shops, but is especially useful in small or moderate sized shops where special machines can not be afforded for many kinds of work.

NEWS AND NOTES

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Annual Meeting, May 22, 1889.

(Discussion of papers continued from p. 282.)

Discussion of Mr. Alexander S. Brown's Paper on "Some Results with Secondary Batteries in Train Lighting." (See p. 301.)

Mr. Geo. B. Prescott, Jr.—I am sure the Pennsylvania Railroad Company deserve a great deal of credit for making the experiments described in Mr. Brown's interesting paper. They have demonstrated one thing very positively, and that is, that an accumulator made entirely on the Planté principle, without active material, applied according to the Faure method, is an impracticable battery for commercial purposes. The improvement in storage batteries of late years, particularly in the past year, has been very great, and the experience which the practical use of batteries has given us goes to show that unless they are handled as if they were a delicate piece of machinery, they will never give very satisfactory results. Wherever accumulators have been properly installed and treated as if they were worthy of being properly cared for, they have been reliable and have fulfilled certain conditions that no other electrical machinery does fulfill to-day.

The improvements in the service of accumulators are not confined to the cells themselves. No matter how good an accumulator may be, if it is not properly installed with suitable apparatus for regulating both the charge and discharge, it will never work satisfactorily. If the accumulator is overcharged, the paste is peroxidized to such a high degree, that it becomes a very fine powder and has not sufficient consistency to hold together, and it simply floats in the form of a powder and gradually deposits in the bottom of the jar. That comes from overcharging, and yet it was only a year ago that overcharging was thought to improve accumulators. We know now, also, that if the cells are allowed to overdischarge they become very heavily sulphated, and the longer they stand in a discharged state the more dense this sulphate becomes; and then if the charging is commenced at what would otherwise be the normal rate, the gas seems to be developed within the interstices of the pellets, and as the sulphate is not in a condition to take up the oxygen, it is liberated and the result is that these pellets are forced out of the perforations, in chunks, so to speak. If, however, the cells are charged and discharged within certain limits, which can be determined for every size of cell, and if any short circuits that may occur through accident or other cause are removed at once, the accumulator, to-day, is a perfectly reliable piece of apparatus.

Mr. C. O. Mailloux—I would like to ask Mr. Brown whether the charging of accumulators at either of the termini of the road has been definitely abandoned in favor of the system of charging on the train.

Mr. Brown—In regard to the charging of batteries on a car or at the terminus, you will understand that the Pennsylvania Railroad still charge at Jersey City. It was the Pullman company I alluded to; they have done away altogether with the charging at either terminus, with the exception of keeping a few spare cells both at Jersey City and Chicago, so that in case the train arrives in Jersey City in the evening, and anything is the matter with the cells or the trays, we simply have a good tray ready to put in its place.

Mr. W. H. Peirce—I would like to ask what was the weight of those cells per lamp, and if there have ever been any tests tending to show the quantity of steam used.

Mr. Brown—I really cannot say much about the Pullman work because I am not connected with that in any way. I do not know just how much steam they require. The weight of a cell is about 50 pounds. We use 12 cells, weighing 600 pounds, to a car provided with 10 lamps—that is, 60 pounds per lamp.

Mr. Prescott—Any objection to making use of steam from the locomotive for driving the dynamo would seem to me not very well founded. We know that the use of steam for heating purposes, for heating cars, is being universally adopted, and steam could be used for driving a small engine to run the dynamo, the exhaust being used for heating the car. Moreover, the amount of steam required to drive the small engine is such an almost infinitesimal part of the total amount of steam generated in a locomotive boiler that it hardly need to be taken into account.

Professor E. L. Nichols—I should like to inquire of Mr. Brown whether he can tell us anything about the average life of accumulator cells used in railway service as compared with the life of the same type of cells doing the same amount of work when stationary. I have had this question asked me many times and have looked in vain for definite information concerning it.

Mr. Brown—I am sorry that I cannot answer; but I have had no experience with stationary cells. My experience has been confined entirely to railroad cells. We calculate our positive plates to last about a year. They are in use almost all the time; they have much more usage than stationary cells; I do not think the motion of the train does them any harm at all. We do not find that the batteries splash. There is some little motion, but being in the centre of the car—they are very long cars, about 65 feet—the motion there is very little.

Mr. W. B. Vansize—I have heard it suggested that there might be some considerations advanced in favor of the oscillatory motion due to use on a railroad car, because of the agitation of the liquid making a more even dispersion; that is, the specific gravity would be more equal at all points of the cell, and, while there might be some detrimental results from the shaking to which the material is subjected, the difficulty in that direction would be, perhaps, more than made up by the equal dispersion of the electrolyte. I do not know that any tests have ever been made to determine this question.

As to the relative duration of a cell whose life is spent upon a car as compared with that used in stationary work, I do not know that it has been determined; but the general opinion is, so far as my observation goes, that the railway cell has a somewhat abbreviated life. The varied attention which the two classes of cells receive would also determine that result to a certain extent. A cell in use on a railroad train would naturally receive a little more careful attention than a stationary cell, unless a system of inspection be in use in connection with the latter.

Mr. Mailloux—The storage battery is never put to a more crucial test than when upon a street car. The requirements of a source of supply of electricity for street car traction are, as everybody knows, very severe. My own experience and observation lead me to believe that if a battery on a car were submitted to the same rates of charge and discharge, and to the same treatment it would last longer than in stationary service. In street cars the work is always necessarily much more severe. There are times when the battery has to withstand a current rate of from 50 to 100 amperes, while in stationary work the same battery would never have a current rate exceeding perhaps 25 to 35 amperes; and yet even under such trying conditions I have known of batteries the positive plates of which were still quite good after fifteen months' use—almost daily use. For a long time the plates were used daily at least once, and sometimes charged twice a day, and yet after fifteen months' use the active matter was not gone and the plates were still good enough to do good work; and this would show that there must be something in the vibration or the shaking of the cells which counterbalances somewhat the hard usage which it receives in the way of excessive rates of either charge or discharge. The particular battery which I refer to was once discharged on short circuit while on the road by the bursting of an armature. While a car was going down a steep grade at a speed of, say, 20 miles or more, one of the armature bands ruptured. At the bottom of the grade the driver turned the switch to put on the current. The car did not move very fast and something began to smoke. The trap door was removed, and one of the motors seemed to be burned up. Upon investigation I found that the current rate of discharge had been sufficient to burn up one of the connecting strips by which the circuit was closed from cell to cell. In other words, one of these strips had acted as a fusible plug, and from its area of section, I concluded that the current rate must have exceeded 300 or 400 amperes. I also found that the field wire, which was No. 4½ Brown and Sharpe, had become heated sufficiently to char the insulation—to carbonize it almost entirely for the whole length. I naturally con-

cluded that the batteries would be ruined. They were taken out and cleaned, and to my surprise I found that while there was some active matter in the bottom of the cells, it was not at all, in quantity, what I expected. In fact, it was so little, that I did not know how much of it was due to that immediate circumstance and how much was due to regular use. At any rate, the batteries were put in service again, except two of them, which were ruined by the melted lead flowing out where the circuit was broken by the destroyed connecting strip. Shortly afterwards, the same battery was again short circuited by some accident in the station. It was short-circuited in such a way that only the field wire of one of the motors was put across the terminals, and we did not know of it until we heard a violent hissing, and observed that the solution was boiling in several of the cells; the circuit was quickly opened. Again I thought the cells might be ruined, but after washing and cleaning they did a good deal of work after that. This goes to show that in the first place, storage batteries will stand a much higher rate of current than they are generally supposed to, with comparative impunity, and it corroborates perhaps the belief which I have, that when once the active matter of a storage battery has become thoroughly receptive by a proper course of treatment, either originally in the making of the battery or subsequently in the treatment of it, that you can do with it a great deal that would ordinarily be considered as abuse of a battery.

Discussion of Mr. W. H. Peirce's Paper on "The Relation Between the Initial and Average Efficiency of Incandescent Lamps." (See p. 309.)

Professor Nichols—It seems as though the number of lamps is rather small from which to draw a general conclusion. It has been the impression that duration tests are only to be relied upon when the number of lamps used is very large indeed. The need of just such work as this I think is very great, and the reliance we can put upon it would depend upon the meaning which we can give to these averages; that is, whether it is found that all the lamps of a single group behaved in the same way. If the lamps were made from widely divergent material, it would seem desirable to go to work again with a very much larger number of lamps.

Mr. Peirce—Some of the different makes of lamp ran along very evenly. The lamps from factories which make a practice of sorting their lamps gave very even results, and those from factories which did not sort their lamps would diverge in candle-power very considerably. In one instance, a lamp supposed to be 16 candle-power varied from about 16 to about 30. I think there is too small a number here to try to establish a law, but there is a sufficient number to show very nearly which way the straws blow. Take, for instance, that B curve; that is almost a straight line. You have got twenty lamps there. I said that the C and the D and the A curves were the most satisfactory, because they seemed to show a general law; but the B is not so satisfactory, because it is a very much contorted curve.

Discussion of Mr. H. Nakano's Paper on "The Efficiency of the Arc Lamp;" Read by Professor Nichols. (See p. 313.)

Mr. Prescott—I would like to ask Professor Nichols if this law that the writer of the paper discovered is independent of the current density. I understood the law to be stated in this way—that the efficiency of the arc lamp depends on the diameter of the carbon, without reference to the current density.

Professor Nichols—I should have said that these experiments were made with constant current, and as nearly as possible with constant electromotive force to the arc. The arc was maintained at about 45 volts, and the current was maintained at about 9 amperes; but quite a little range of voltage and current in the lamp showed surprisingly small changes in the efficiency. Probably toward the end of the test there was not the care taken to hold the current and voltage constant that would have been taken if the efficiency had been found sensitive to changes in this respect, but the law holds true strictly where the current and voltage are maintained constant.

Mr. Garver—In some experiments which I made with arc lamps for 20 amperes I used 7-16 carbons in summer, but in the winter, in order to make them last longer, I used larger carbons. We found in our experience that the light was not as good, and, consequently, we would have to increase the current. However, when we got harder carbons they lasted better. We observed also, in that case, without measurements, that the light was not so good with the hard carbon as with the soft carbon. I would like to ask if anything of the kind has been observed by others.

Professor Nichols—It was not the intention to go into the question of different carbons, but in starting the investigations we simply took what carbons happened to be available in the laboratory, of different sizes, in order to carry the work on. It was taken up originally as practice work, and I did not know at that time that it would ever come to the light, because I did not expect so good a result as was obtained; but all the carbons were probably carbons of excellent quality, but they were of different makes, made in this country and Europe.

The President—I would add a word just on this point from my own experience. I think the density and hardness of the carbon have an effect on the luminosity; and practical experience, without even referring to refined measurements, is that if a carbon is too hard for the current, the luminosity is so much lessened that people complain at once, although the voltage and current remain the same. I can confirm what Professor Nichols says also in regard to changes in the length of the arc not changing the luminosity very much beyond a certain separation when the light seems to go out freely, and as it mostly emanates from the carbon ends themselves, a little separation, more or less, will not make a great difference in the effects. But there was one point I would like to make just here, and that is that it would be interesting to know exactly what the rate of combustion was in the different cases, that is, the total consumption of carbon, large and small. Of course a part of the cost—the practical cost—is the rate of consumption of carbon, and sometimes we can sacrifice a little ligh by using a larger carbon and getting a longer life of carbon, since the carbon costs something in the running of the lamp. This gives rise to the question as to whether the combustion of the carbon itself does not have to do with the efficiency, or illuminating power—whether, in other words, the carbon is not to be regarded in part as a piece of coal, which, by burning, gives out light, and that if it burns rapidly it gives out more light in a given time than if it burns slowly; consequently, with a low current density and the combustion of the carbon restricted, we lose that effect, and depend on the current altogether to produce the effect. Take a piece of coal out of a furnace, and if we could burn it in oxygen, and keep its temperature high during the burning, we would get a large emission of light; and we also know that the actual linear distance of carbon consumed in an hour represents a considerable rate of combustion. At a certain rate of burning there must be a yield in efficiency as to total radiation of light, due entirely to the combustion effect in the carbon, without the assistance of the current, the current merely maintaining the carbon at that temperature, which permits this source of efficiency to exist.

Mr. Weston—I understand that the experiments were made with but one lamp. Experience has shown, I think, that the efficiency of an arc lamp is very much increased where the power of the light is increased. If I remember rightly, some experiments I made in 1875 and 1876 showed that to a very marked extent; and I think other experiments, probably earlier than mine, showed it. So that the efficiency as it stands for an ordinary commercial lamp to-day is not anything like what we may get if we make lights larger. How far that would extend it is somewhat difficult to say, and as Professor Nichols has all the appliances for making these measurements, including dynamos, I think it would be a very good thing if we could get some facts in regard to efficiency of lamps running up to 100 or 200 amperes, instead of 9 or 10. It would probably throw a great deal of light on the matter. The small amount of luminous energy—that is, useful energy—in proportion to the total energy employed is a sad thing always. That, together with the inefficiency of the steam engine, shows how much we have to do. There is no lack of work to be done in this field.

Professor Nichols—In presenting this paper I have offered it, not as an exhaustive investigation of the subject, but rather as pointing out a method or line of work which may be applied with a good deal of benefit to the study of the light-giving power of various illuminants; and that, undoubtedly, in order to make it complete, it ought to be worked out for the efficiency as a function of the length of arc, independently again as a function of current, and then those could be combined, so as to give it as a function of the energy for a constant length of arc. In short, it ought to be worked out in all the conditions under which lamps can be used. Here we have only worked it out for a single condition, because that was convenient to us—the ordinary long arc lamp of to-day.

Professor Wm. E. Geyer—May I ask Professor Nichols whether any attempt was made to ascertain if, in the part which he calls luminous energy, any appreciable amount was energy other than luminous—that is, what is ordinarily called actinic? I should think it not unlikely that, in a light centre, as an arc light, an appreciable amount might be other than luminous, which would reduce all those figures slightly; but the effect would probably be greatest on those which are lowest on the column, and probably less on those which are near the top of the column.

Professor Nichols—Very careful corrections were made for the dark rays—the waves of longer wave length than the red—which were able to pass through the alum, and also the light-giving rays, which we still observed, but the energy of the ultra-violet is so very small when measured on the thermopile that we regarded it as negligible.

.... From an industrial point of view, one of the most noteworthy results of the growth of knowledge in recent times is the reduction in the quantity of fuel burned to produce a given result. —*Industries.*

... The electric light has so dazzled the minds of men with its brilliant possibilities, they are hardly able to look beyond it to consider the greater possibilities of electric motor power.—*A. R. Foote.*

COLLEGE NOTES.

Columbia College.

SCHOOL OF MINES COURSE IN ELECTRICAL ENGINEERING.

A course in electrical engineering has been established in the School of Mines, open to graduates of that school and of other institutions of like grade and standing.

The following preliminary announcement is made by the college authorities :—

The officers of instruction and government are as follows :—

HENRY DRISLER, LL.D., Acting President of Columbia College.

WILLIAM P. TROWBRIDGE, Ph.D., LL.D., Professor of Engineering.

FRANCIS B. CROCKER, E. M., Instructor in Electrical Engineering.

MICHAEL PUPIN, A. B., Assistant Teacher in Electrical Engineering.

GEORGE F. FISHER, Registrar.

The full course will occupy two years ; there is a partial course which can be completed in one year.

The course of instruction will comprise :—

I. Lectures.—1. General Principles of Electricity: Theory, Laws, Sources, Measurements, and Nature of Electricity.

2. Principal Phenomena of Electricity: Heat, Light, Magnetism, Attraction, Sensible Energy or Power, Induction, Chemical Action.

3. Simple Applications of Electricity: Dynamos, Motors, Electric Light, Telegraph, Telephone.

4. Theory of the Dynamo and Motor.
Dynamo and Motor Regulation.
Transmission and Distribution of Power.
Electric Railway Systems and Locomotives.
Telegraph Systems, Duplex, Multiplex, Printing, Autographic and Submarine.
Telephone Systems.
Electro-chemistry, including Theory of Primary and Secondary Batteries.
Electro-metallurgy, Plating, Reduction, Separation of Metals.
Electricity applied to Mining.
Torpedoes, Stationary and Movable.

II. Text Books.—Study of, and recitation on standard electrical text books covering principles and applications of electricity, and including memoirs or theses at such stated times and on such subjects as may be assigned.

III. Conferences.—Examination and explanation of practical electrical machines and models.

IV. Visits.—Examinations and reports of visits to electrical stations, factories, and plants.

V. Workshop Practice.—In actual construction of electrical apparatus and machines.

VI. Design.—Designing and drawing of electrical machines and apparatus for construction.

VII. Specifications.—Design, drawing and preparing specifications for electrical plants: lighting, power distribution and transmission, railway, telegraph, telephone, and electro-metallurgical.

VIII. Testing.—Practical work in setting up and use of instruments for testing.
Efficiency and constants of electrical machinery and apparatus.
Resistance of machines and land and submarine lines.
Insulation of machinery and lines.
Location of grounds and faults in machines and lines.
Photometric tests of lights, arc and incandescent.

IX. Mathematical Physics.—Mathematical relations of electricity, light, heat, magnetism, and mechanical energy.
Mathematical determination of electrical laws, units and constants.
Mathematical theory of flow and action of intermittent and alternating currents.

X. Original Investigation.—Thesis on an assigned subject, such as efficiency of machines, regulation of dynamos or motors, storage batteries, etc.

XI. Examinations and Fees.—Graduates of the School of Mines, and of other institutions of like grade and standing, will be admitted to the course without examination. But in cases where there may be any doubt of the proficiency of such graduates they may be required to pass such examinations as shall be prescribed by the faculty.

REGULAR COURSE.

Fees for the regular course, entitling the student to all the privileges of the school, per annum.....	$150
Matriculation fee........	5
Graduation fee..................................	25

PARTIAL COURSE.

Fee for the partial course, attendance on lecture room and other special instruction per annum, for each hour per week of such instruction up to six..	$25
Matriculation fee............	5
For the use of drawing academy..................	25
For the use of laboratories or either of them.......	50

NOTE.—Application has been made to the trustees for authority to admit to these classes students who are not graduates of technical schools upon their passing the necessary examinations.

For particulars as to the course of instruction, etc., in electrical engineering, apply to Professor W. P. TROWBRIDGE, School of Mines, Columbia College, 49th street, corner Fourth avenue, New York.

For general information and circulars, apply to GEO. F. FISHER, Registrar, School of Mines, Columbia College, 49th street, corner Fourth avenue, New York.

The appointment of Mr. Francis B. Crocker as instructor in the course of electrical engineering at Columbia College, is regarded in electrical circles as a very judicious one.

Mr. Crocker is well known among electricians, as one from whom earnest work may always be looked for with confidence. It will be remembered that the now celebrated C. & C. motor owed its protection to the association of Mr. Crocker with Mr. G. Curtis, in a series of experimental applications of electricity, and one of the most useful papers ever read before the New York Electrical Society, of which Mr. Crocker has since been elected president, although it was very unpretentious, was that on "A Practical Method of Calculating and Designing Dynamos and Motors." Mr. Crocker is also an active member of the American Institute of Electrical Engineers, and his paper on "Chemical Generators of Electricity," read before that body at its annual meeting of 1888, was received with the highest appreciation.

Mr. Michael Pupin, who is to assist Mr. Crocker, also has a record of no mean order. His reputation as a first-class mathematician is already established. While holding among other honors the Tyndall fellowship, Mr. Pupin studied for a time under Helmholtz in Berlin.

Columbia College is to be congratulated on the wisdom of its selection, and it initiates its new and important course with the confidence and good wishes of the electrical profession and the public.

Ohio State University.

INSTRUCTION IN ELECTRICAL ENGINEERING.

Instruction in the commercial applications of electricity has been given at the university for some years in connection with the regular work of the department of physics. The increasing interest and importance of such work was this year recognized by the legislature, and an appropriation was made for the erection of a building and the securing of the necessary machines and instruments for a full and practical training. The building will be completed, and the machinery in position at the opening of the fall term, September 11th, 1889.

The course of study covers four years, and those completing it receive the degree of mechanical engineer, their diplomas stating that they have completed the course in electrical engineering. Admission to the course is given on the same conditions as to the other engineering courses of the university.

The course in electrical engineering is as follows :—

FRESHMAN YEAR.

Fall term.—French, Meras and Duffet's grammar, *five hours a week;* chemistry, lectures and Norton's chemistry, *four hours;* mathematics, Wells' trigonometry, *three hours;* English, Welsh's complete rhetoric, *two hours;* mechanical laboratory, *two hours.*

Winter term.—French, grammar continued, Masson's French classics, *five hours;* mathematics, Wentworth's college algebra, *three hours;* chemistry, lectures and Norton's chemistry, *two hours;* English, Welsh's complete rhetoric, *two hours;* mechanical laboratory, *two hours;* drawing, free hand drawing, *one hour.*

Spring term.—French, Masson's French classics, *five hours;* mathematics, Bowser's analytical geometry, *three hours;* English, Welsh's complete rhetoric, *two hours;* mechanical laboratory, *two hours;* drawing, free hand drawing, *one hour;* lettering, *two hours.*

SOPHOMORE YEAR.

Fall term.—Mathematics, Charles Smith's analytic geometry, *five hours a week;* physics, Anthony and Brackett's physics, and lectures, *five hours;* projection drawing, Faunce's mechanical drawing, *three hours;* physical laboratory, *two hours;* mechanical laboratory, *two hours;* rhetoricals.

Winter term.—Mathematics, Bowser's calculus, *five hours;* physics, Anthony and Brackett's physics, and lectures, *five hours;* drawing, Church's descriptive geometry, *three hours;* physical laboratory, *three hours;* rhetoricals.

Spring term.—Mathematics, Bowser's calculus, *five hours;* physics, Anthony and Brackett's physics, and lectures, *five hours;* drawing, Church's shades, shadows and perspective, *three hours;* mechanical laboratory, *three hours;* rhetoricals.

JUNIOR YEAR.

Fall term.—Mechanics, Bowser's analytic mechanics, *five hours a week;* physics, lectures and laboratory, *three hours;* least squares, *one hour;* mechanism, *two hours;* designing and drawing, *five hours;* rhetoricals.

Winter term.—Mechanic's, Bowser's analytic mechanics, *five hours;* mechanism, *five hours;* physics, lectures and laboratory, *five hours;* rhetoricals.

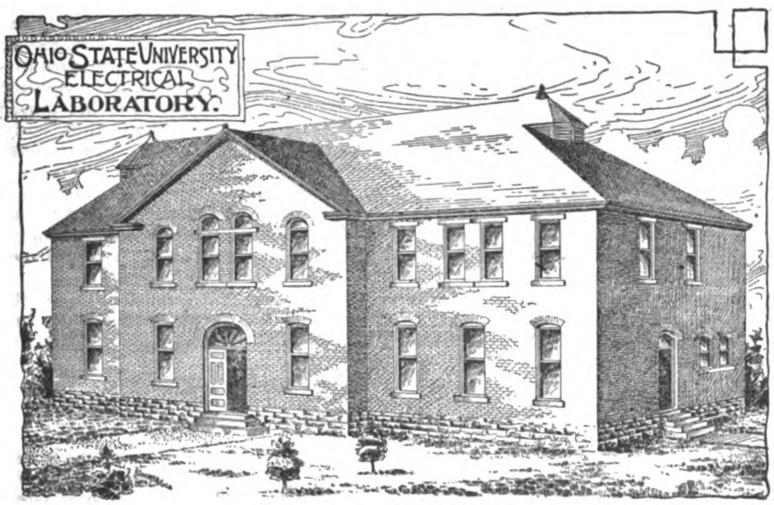
Spring term.—Strength of materials, Wood's strength of materials, *five hours;* physics, lectures and laboratory, *three hours;* mechanism, *two hours;* technical drawing, *five hours;* rhetoricals.

SENIOR YEAR.

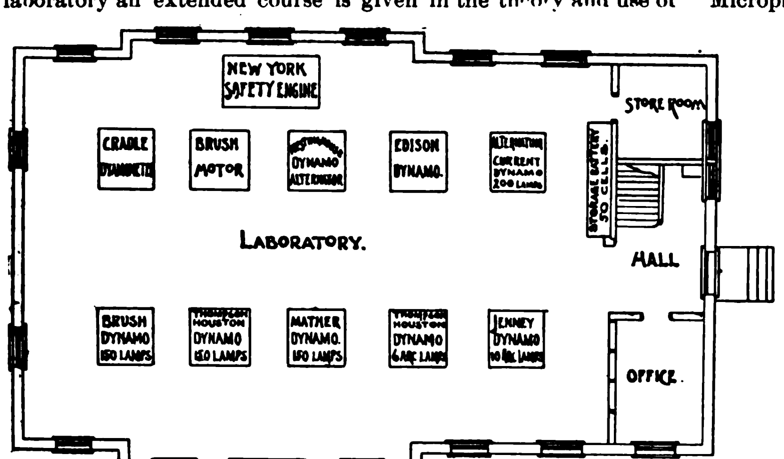
Fall term.—Electrical engineering, Thomson's dynamo-electric machinery, and lectures, *five hours;* thermo-dynamics, *five hours;* technical drawing, *three hours;* electrical laboratory, *three hours.*

Winter term.—Electrical engineering, lectures, *five hours;* prime movers, Rankine, with lectures, *five hours;* technical drawing, *three hours;* electrical laboratory, *three hours.*

Spring term.—Electrical engineering, lectures, *three hours;* mill work, Rankine, with lectures, *five hours;* technical drawing, *five hours;* electrical laboratory, *three hours.*



The objects aimed at in this course are: first, to afford the student a thorough training in the theoretical principles which underlie his chosen profession; secondly, to give him skill in the use of instruments, and practice in the handling of dynamo machinery. The work in mathematics and physics prepares the student for the theory of the steam engine and other prime movers, and for the theory of the dynamo and motor, which are fully discussed in the senior year, with all the allied topics in the commercial distribution and use of electricity. In the physical laboratory an extended course is given in the theory and use of



instruments in mechanics, heat, light, electricity, and magnetism. In the mechanical laboratory, a general course of practical instruction in the use of hand and machine tools in wood and metal working is provided. In the electrical laboratory, practical training is given in the setting up, adjustment, and running of the steam engine, and of dynamos and motors of all classes. For this work a New York Safety power steam engine is provided, with dynamo machines of commercial size from the Brush, Thomson-Houston, Mather, Edison, and Westinghouse companies, motors from the Brush and Mather companies, and a 50-cell Brush storage battery. There are also provided steam engine indicators, dynamometers, and various forms of commercial electrical measuring instruments. In the physical laboratory are standards, and instruments of the highest quality, with which work may be done with any desired precision.

The electrical laboratory is specially arranged for the experimental and practical work of the course. The building is about 45 by 75 feet. The arrangement of space on the ground floor is shown below. The second floor has a lecture room, photometer room, library, and three measurement rooms. Cables run to the physical laboratory rooms in the main building of the university where the standard measurement instruments are placed.

The establishment of the full electrical engineering course, with its liberal equipment, is largely due to the initiative of Dr. B. F. Thomas, professor of physics in the university, who has directed the electrical instruction hitherto so successfully given at Columbus, and who will have the direction of the full course now to be established.

EXPENSES.—There is no charge made for tuition. An incidental fee of $5 a term, or $15 a year is charged, and special fees are required of those working in the laboratories. In the physical and electrical laboratories the fee is $7 per term; in the mechanical laboratory, $5 per term. Board and rooms may be had at $4 to $5 a week in private families, and in clubs at $3.

For the catalogue, containing more detailed information about the university, address William H. Scott, president, or Alexis Cope, secretary, Columbus, Ohio.

Massachusetts Institute of Technology.

The graduation exercises of the Massachusetts Institute of Technology, took place in Huntington Hall, Rogers' Building, May 28. They were of the usual simple character and designed to exhibit as far as possible the work of the school in its various departments. After a few introductory remarks by the president, General Francis A. Walker, abstracts of Theses from the various departments were read by the students.

The electrical course was represented by Mr. F. W. Bradley, who together with Mr. H. Hunt, made during the last term an experimental study of a Weston dynamo. After the reading of the abstracts, the Rev. Phillips Brooks, D. D., delivered an eloquent address to the graduating class, welcoming them to the army of actual workers.

After the conferring of degrees by the President the friends of the Institute were invited to examine the laboratories and the various departments of the school. Samples of shopwork and drawings were on exhibition, and also the work of the Lowell School of Practical Design.

The titles of the Theses presented by the candidates for the degree of Bachelor of Science, in the department of electrical engineering, were as follows:—

"An Experimental Study of a Weston Dynamo Machine," F. W. Bradley with H. H. Hunt.

"The Efficiency of Alternating Current Transformers," J. N. Bulkley with G. B. Lauder.

"An Investigation of the Motions of the Electrodes of the Microphone Transmitter," F. L. Dame.

"The Efficiency of Alternating Current Transformers as determined by the Electrometer Method," J. P. B. Fiske with H. French.

"The Distribution of Light of Incandescent Lamps, with Efficiency Measurements," E. W. Gannet with H. M. Hobart.

"A Study of Specific Inductive Capacity, with Various Rates of Charge," G. U. G. Holman.

"Experiments upon Induction Coils for Telephone Purposes," F. A. Laws.

"A Study of the Regulation of the Thomson-Houston Constant Potential Dynamo," C. W. Pike with F. P. Whitney.

"An Experimental Study of the Efficiency of Commercial Storage Batteries," C. W. Power with G. W. Rounds.

"A Study of the Thomson-Houston Electric Motor," C. H. Warner with A. E. Truesdell.

From the physical department:—

"The Inverse Electromotive Force of the Voltaic Arc," A. D. Kinsman.

There were 75 successful candidates for the degree of Bachelor of Science—one less than last year. Of this number 17 were from the department of electrical engineering.

During the last few weeks of the term, the fourth year electricals have received lectures from various gentlemen connected with the profession in a practical way.

Mr. Edgar, of the Boston Edison Co., speaking on the "Edison System."

Mr. Moody, of the Thomson Electric Welding Co., on "Electric Welding."

Mr. Hadaway, on "Incandescent Lamps."

Mr. Blodgett, of the Boston & Albany R. R., on "Train Lighting by Electricity."

Mr. Puffer, Instructor in Physics at the Institute, on "Dynamo Coupling and on some special tests with respect to dynamo design."

Mr. Blake, of the Sprague company, gave a short series of lectures on "Electric Motors."

Professor Holman has been giving to the third year electricals a practical course of lectures on electrical measuring instruments, treating of the tangent galvanometer and its various modifications, sensitive galvanometers; electro-dynamometers, and other forms of metrical apparatus. The course is to be continued next term.

The electrical department has received from Mr. Otto Schall, its former mechanician, a very fine tangent galvanometer of the Helmholtz Gaugain form, made after designs by Professor Holman. It is his intention to have it so wound as to be sensitive to .01 ampere. The department also has under construction by its mechanician, two quadrant electrometers to be used in connection with work on alternating currents.

The work of Messrs. Bulkley and Lauder in connection with that of Messrs. French and Fiske, forms a very interesting study on the efficiency of alternating current transformers.

The first two gentlemen used the calorimetric method, employing a large ice calorimeter.

Messrs. Fiske and French used the electrometer method. They at first tried to measure the work done in the coils by the method given by Mascart and Joubert; the results obtained for the efficiency did not agree with those given by the calorimeter by about ten per cent. A different method of measuring the work in the primary circuit, was then tried, viz.: that suggested by M. Potier, the results afterwards obtained agreed very well with those from the calorimeter tests. The method employed by Messrs. Fiske and French has the advantage of quickness when once everything is in working order; but much time is wasted on account of the perverseness of the instruments employed.

From the results of the work of Messrs. Lauder and Bulkley, the calorimeter method seems to possess an advantage in point of accuracy, but it has the distinct disadvantage of requiring a long time to make the test.

Owing to the rapid growth of the mechanical and electrical departments, the present laboratory has become much too small; 150 students must be accommodated the coming year. To meet this demand the Institute is preparing to put up a new building. It will have six working floors, the two lower devoted to the mechanical laboratories; the second two to the mechanical engineering drawing rooms, and the upper two to the civil engineering department.

The equipment of the laboratory will contain a Harris-Corliss and also a triple expansion engine, now building by Allis, of Milwaukee. Both of these will be available for engine tests; the latter will be so arranged that it can be run in various combinations.

Steam for the engines and other purposes will be conveyed to the building through underground pipes from the boilers in Rogers' Building, a distance of about 1,000 feet.

Rose Polytechnic Institute.

The annual catalogue of Rose Polytechnic Institute, Terre Haute, Indiana, contains the following information respecting the electrical instruction afforded there.

"A special course in electricity and its applications is arranged in connection with the course in mechanical engineering. It is believed that those who wish to fit themselves for the intelligent manufacture of electrical apparatus and machinery and for designing the same, or for the installation and management of electric light and power stations, for expert work in connection with telegraph and telephone service, etc., will especially need the greater part of the training which the course in mechanical engineering affords. On this subject the most distinguished electrical engineer of the age remarks as follows:" :—

* * * I endeavored to impress upon engineers and architects that architects made a great mistake in not being engineers—in not qualifying themselves as engineers, and doing the work of engineers. That architects do not do their duty to their clients in not being engineers and understanding the engineering of their own works, and making engineering science, particularly the dynamics of engineering, an essential part of the training of an architect. It is not necessary to make any animadversion, I think, upon electrical engineers in this respect. Electrical engineers know well that they must, before all be engineers. They must be engineers and they must learn electricity.

To young persons who have a taste for electrical machines * * * a word of advice may be useful. Every young person who has a fancy for electricity thinks he would like to be an electrical engineer. They think electrical engineering is all ether and electricity. Now I have continually to impress upon anxious fathers and mothers that their boys must condescend to learn something of gross ponderable matter, and that electrical engineering is not confined to ether and electricity, but mechanics also is an essential part of the subject. It is, I think, an important point this—that the electrical engineer, or the youth or aspirant to that honorable profession, ought to learn mathematics and dynamics after having obtained the elements of a good general education. He ought to learn mathematics and dynamics well. Then a good deal of chemistry and regular mechanical and civil engineering should all be learnt; and electricity learnt besides. * * * I am perfectly sure that if the youth is qualified in other departments, the mere addition of electricity to the education of a competent engineer will not take so very long a time as might be imagined, and that the merely educational part of the work will not be protracted unduly by adding electricity to the branches learnt in general engineering.[1]

The course in electricity is therefore built upon this idea; the election is made at the beginning of the sophomore year and a part of the practice time is devoted to electricity from that time until the end of the course, in addition to the physics and laboratory practice of the junior and senior years, during which a large share of the time of the students is devoted to the subject.

Gordon Technical College, Geelong, Victoria, Australia.

The annual report of Gordon Technical College, Geelong—an institution founded as a memorial to the late General Gordon—exhibits the wisely practical cast of mind prevailing in the British colonies. The college is devoted to engineering and technical training, the training that is most needed in relatively new communities. The foundation stone of the college building was laid June 20th, 1887, and the annual report is to December 31st, 1888. The college was formally opened on the 14th of November, 1887. The courses of instruction have embraced the following subjects:—free hand drawing, architectural drawing, mechanical drawing, painting, book-keeping, mathematics, short-hand, telegraphy (including elementary electrical instruction), French, German, and chemistry. The tuition charges are but nominal, and the railways issue tickets at reduced rates to pupils from the neighboring country. The instruction has been availed of, up to the date of the report, by persons employed in the following trades:—masons and bricklayers, carpenters and joiners, painters and paper-hangers, plasterers, fitters, turners and smiths, teachers, clerks, coach-builders, shop employés, coopers, printers, and other miscellaneous occupations (including domestic service) to the number of 224. A great amount of work seems to have been achieved at small cost in money—the entire expense to December 31, 1888, being less than $13,000 for the college building and less than $2,700 for maintenance. A distant observer derives from the report under notice, and from recollection of a report of proceedings issued before the completion of the college building, that our Australian friends around Geelong, have with signal success created a memorial to the chivalrous Gordon, of a particularly felicitous kind, in providing for the workers of their community the means of improving the quality of their service and enriching their own lives through the cultivation of their mental powers. It is gratifying to read that an additional building for a chemical laboratory was planned and about to be built at the time of the annual report.

ELECTRO-PHOTOGRAPHY.

We often hear the expression: "I can see through a board,—when it has a hole in it." The last half of this saying can, in future, be omitted, since it has been proved possible to transmit an image to a distance electrically, like sound, through a telephone. Late this afternoon our editorial staff was telephonically invited by one of the present renowned firms, to witness some experiments with a new invention which would reproduce, electro-photographically, images of objects removed at a great distance. As we entered the dimly lighted room, we found there gathered, the inventor, Mr. Körzel, of South Germany, and a small but distinguished circle of scientific and technical spirits. The explanation of the photoscope, as the new apparatus is called, had already begun.

We will here give a description of this highly interesting piece of apparatus, as far as our recollection of the words of the inventor, a comparatively young man, allow.

As foundation for the apparatus, is used the ordinary house telephone. Above the diaphragm aperture we notice a lens, similar to the objective of a photographic camera, and above this, a translucent glass plate in an elegant frame. At the right and left of the objective are two incandescent lamps with silvered mirror reflectors. The lamps are lighted by a specially constructed battery. This is the outward appearance of the apparatus, which in truth, leaves a very favorable impression upon the observer.

The objective serves for taking the picture of the person using the telephone, while the incandescent lamps illuminate his face. Upon the glass plate above, is thrown the image of the person using a corresponding instrument at the other end of the line. It should be stated here that in using the telephone, both parties stand about 30 cm. from the instrument,—something that, by the way, with our ordinary telephones, is to be recommended. Upon the internal construction of the apparatus, on the exceptionally fine work of which, we will speak later, Mr. Körzel says:—

In the photoscope there is a changing of light vibrations into electric vibrations, similarly as takes place in the microphone in sound waves. It was the inventor's fortune to find in bromgelatine, a substance which in connection with the well-known property of selenium makes possible the transmission of light.

1. Inaugural address of Sir William Thomson, President of the Institution of Electrical Engineers, London, England. Delivered on January 10th, 1889.

Some time ago, in a later year of the last decade, Willoughby Smith, in London, was successful in establishing the fact that the electric conductivity changed when light fell upon a selenium cell, as John Perry communicated to the Society of Arts in 1881. Mr. Körzel went on to say, that the image of the speaker was "collected" by the bromide of selenium gelatine, and, at the same instant, by means of an especially constructed lens system, was thrown upon the translucent glass plate of the other telephone. All this was done through the same conducting wire, through which the speech was transmitted.

After this explanation began the extremely interesting exhibition of the apparatus.

Herr. Körzel, without the knowledge of the postal authorities, connected his photoscope to a telephone, and had the central office connect him with a business friend in Potsdam, who likewise was provided with a photoscope. The moment the Potsdamer stepped to the apparatus, the ground glass plate showed an excellent portrait of him, which when compared with his photograph, was easily to be identified. It was extremely interesting to observe the motions of the speaker in Potsdam. According to the course the conversation took, we noticed now a nodding; now a violent shaking of the head; now an assenting smile, and then a dissenting earnestness of the whole face. The picture appeared like a photograph endowed with life.

To assure us of the genuineness of the apparatus, we were asked to stand one after another, in the space lighted by the lamps, and the gentleman at the other end, as the separate men stepped up to the telephone, gave such characteristics of each, as the face, style of beard, spectacles, hair, etc., with such exactness, that a preconcerted deception was absolutely not to be thought of.

Now, of course, it is not to be imagined that transmission of images is confined to the face. We were simply astounded, as we saw on the glass plate, the image, although, of course, a reduced one, of a newspaper, and from the comparatively great distance that we stood, could read at the top very distinctly the title and date.—*Centralblatt für Electrotechnik.*

THE INTERNATIONAL CONGRESS OF ELECTRICIANS AT PARIS.

The International Congress of Electricians will be held in Paris, beginning on the 24th of August next, and continuing for eight days. Respecting the objects of the congress, M. E. Mascart, president of the committee of organization, has issued the following letter:—

"The International Congress of Electricians held at Paris in 1881 marks an important date in the history of electricity. The establishment of the practical units has had a most important and far-reaching influence on the development of the science and industry. The great rapidity and ease with which the decisions of the congress were accepted in the workshop, as well as in the laboratory, demonstrate the utility of large scientific gatherings where all the most competent may unite in their efforts for the common good.

"The International Exhibition of 1889 offers a natural occasion to continue and to complete the work of 1881; not that the new congress will have to treat of problems of an order as general, or as high, but many questions still remain upon which an understanding, or, at least, an exchange of views, is desirable. In the programme which it has prepared the commission of organization has not pretended to indicate all the debatable points, and still less to impose any limits on the field of activity of the congress. It has only desired to call attention to those departments which appear to it to be of the most general and immediate interest. We believe that we express the unanimous sentiment of electricians in putting among the foremost questions the following: "Practical measurement of electrical energy in all forms; measurement of the current in absolute values with a standard which is easily reproduced; electric meters for continuous and alternating current; practical measurement of light; determination of the constants of a machine from the commercial points of view, etc.

"We hope that the scientists and manufacturers who may have contributed to the progress and applications of electricity, and all persons who are interested in this new branch of human activity will answer our appeal by contributing and giving to this meeting the importance and authority of that which preceded it."

According to the rules adopted for the regulation of the congress, all those may become members who have signified their intention to the president of the commission of organization before the opening of the session, or who may register during the continuance of the same, and on payment of a fee of 20 francs. All members of the congress will receive a card, which will be delivered to them by the commission of organization, and which will be strictly personal and not transferable. A full account of the proceedings of the congress will be published, and each member will be entitled to a copy. Those desiring to attend are requested to address M. Mascart, 44 Rue de Rennes, Paris.

Members who send in their subscriptions will receive a personal card and a series of notices relating to the programme to be followed.

A LETTER FROM MR. LOWREY

The following letter from Mr. Grosvenor P. Lowrey was received too late for insertion in its proper place under "Letters to the Editor." We are extremely glad to have received it, and to print it in this issue.

To the Editor of THE ELECTRICAL ENGINEER.

Sir:—In your last number you quote from my argument in the Edison-Westinghouse case, at Pittsburgh, certain remarks touching the knowledge which it was possible Mr. Pope could have possessed in February, 1879, about Edison's proposition to divide the electric light commercially; and you cite a publication in the *Scientific American* describing a particular Edison device, known as the "thermal regulator," prior to the issue of the American letters patent upon it.

The subject which I was dealing with was the state of the art and of scientific opinion affecting incandescent electric lighting in 1878; and I was considering the writings of Preece and others, who were of opinion—without reference to means suggested—that the electric light could not be divided commercially, a denial which was persisted in after the Upton article in *Scribner*, of February, 1880, had described and delineated the Edison incandescent (filamentary) lamp, by which that division was then, and has ever since, been done. Mr. Pope, in a letter written at the time, had expressed a like judgment, and he seemed well supported by contemporaneous scientific opinion. The thing having been done, however, and Mr. Pope on the stand as a witness, he explained, under cross-examination, that he had had in mind, at the time of writing, only the "thermal regulator," and that he meant that the problem could not be solved that way. In looking hastily into the history of the long forgotten "thermal regulator," I found that the United States patent for it did not issue until some months after the printing in England of Mr. Pope's letter; and I concluded (as it now appears incautiously) that Mr. Pope (in the lapse of time and the excitement of contest) had achieved that kind of foresight which, according to the old play, is generally denied to us—

"The Spanish fleet thou canst not see,
Because it is *not yet in sight.*"

This, as now appears, was a conclusion not justified by the facts, and I take great pleasure thus to make the *amende honorable* to Mr. Pope, for whose intelligence and candor I have always had a high esteem.

The other gentlemen—non-believers in anything good coming out of Menlo Park—having continued their denials too long, and made them too sweeping, seem to be shut out from sanctuary under the "thermal regulator" explanation; and the main proposition of my argument—under consideration at the moment of the discursive reference to Mr. Pope—remains unassailed and unassailable, viz.: that while Mr. Edison was maintaining that the light could be divided, and was by wide experiment and ratiocination seeking a plan and the means, all the others, except Sir William Thomson, were broadly denying its possibility. Doubtless some of them wish they, too, had seen the *Scientific American*, which Mr. Pope saw.

Yours, very truly,

GROSVENOR LOWREY.

15 Broad street, New York, June 27th, 1889.

NOTES FROM GERMANY.

THE *Centralblatt für Electrotechnik* goes to the trouble and expense of printing a communication, with cut, giving an alleged explanation of the Tesla motor, which, as the writer says, has never had its practical construction explained, in spite of the fact of its being so well known. The person sending this communication is evidently not posted in the literature of his subject. The *Centralblatt* itself published in February last, a long article on this motor written by Mr. Tesla himself, and which, by the way, appeared in THE ELECTRICAL ENGINEER, as long ago as June of last year.

PROFESSOR DR. A. VON WALTENHOFEN was lately chosen president of the Elecktrotechnische Verein in Vienna. He was also, at the same time, appointed examining commissioner for electrotechnic in the department of commerce.

A BERLIN morning paper contained recently an account of an accident which occurred in that city at a conspicuously ill-chosen spot. A workman engaged in painting the poles carrying the electric light wires for the exhibition of life-saving appliances, accidentally made a short circuit and was thrown to the ground, sustaining severe injuries. It is rather curious that such an accident should occur immediately in front of the building containing the best appliances for the protection of life and limb.

THE heating of tightly wound wires has, as the editor of the *Centralblatt* shows, a very great influence upon their insulation—an influence that engineers have very little, if at all regarded. The results of his experiments would seem to show that this influ-

ence might be very injurious at times when a high insulation is demanded.

A short piece of wire was wound in the form of a flat spiral, placed between two gold plated brass plates, and subjected to a pressure of 2 kg. At 17° the insulation resistance was found to be 14 megohms. After warming to 60°, the resistance of the insulation had fallen to 410,000 ohms. Forty hours afterwards the resistance had again risen to 8.2 megohms. The failure of the insulation to show, after cooling, its original high resistance was largely due to atmospheric conditions at the time. Other experiments verified this first result, which if not new, is certainly not generally familiar to the profession.

In a late meeting of the Polytechnic Verein, in Munich, Professor Dr. Voit, gave, by request, a statement of the electric lighting in that city. In his report he made what he probably intended to be taken as an astounding statement when he said that from the beginning of the year 1885 to the end of 1888, the electric lighting had increased from lamps giving 160,020 candles to a number giving 900,896; that is, a five-fold increase. These figures may be large for Europe; but compared with statistics of many American towns of not near the population of Munich, they sink into insignificance both as to actual number of candles and rate of increase.

To anyone who has seen the Isar flowing, as it does at Munich, with frightful rapidity past or rather through the city, another statement of Professor Voit will sound a little remarkable. He says that for the lamps at present in use in Munich, the power is furnished as follows:—256 arc and 6,687 incandescent from gas motors; 238 arc and 14,610 incandescent by steam engines; and 90 *arc and* 1,934 *incandescent by water motors.* The fact that turbines and water motors of any efficient form are not used to a greater extent where conditions are so exceptionally favorable, seems very surprising.

OBITUARY.

Gaston Planté.

We have to chronicle the death at Paris, May 24, of M. Gaston Planté, the distinguished inventor of the lead secondary battery.

M. Planté was but 55 years old. He was born at Orthez, in the Pyrénées, April 22, 1834, and received his scientific education at the Conservatoire de Arts et Metiers in Paris, where he was afterwards appointed assistant to M. Ed. Becquerel in the laboratory. He subsequently entered the service of Messrs. Christofle et Cie., as chemist, in which position he made opportunity to carry on investigations into the phenomena of "polarization" in batteries; his studies and experiments eventually leading to his discovery of the lead accumulator, an achievement which is justly deemed to be the starting point of all the development of secondary batteries hitherto accomplished. Beginning with the study of voltmeters, M. Planté was lead into and followed out, through many years of experiment, investigation touching the accumulation and transformation of the energy of the voltaic battery through secondary currents. The results of this important and valuable work appeared from time to time in *Comptes Rendus*, and were afterwards printed in a book entitled "Recherches sur l'Électricité," an English translation of which by Mr. P. B. Elwell, published by Messrs. Whittaker & Co., under the title "The Storage of Electrical Energy" was noticed in The Electrical Engineer, of April, 1888. During the later years of his life, M. Planté gave much attention to the study of atmospheric electricity.

M. Planté was a striking example of the man of science, pure and simple, quite indifferent to the commercial spirit, giving no thought to enriching himself through his discoveries, and little regardful of the many honors bestowed upon him by scientific societies and by the French government. His modest nature kept him to the last in the walks of a quiet and retired life, brightened by the cordial appreciation of his scientific and personal friends. It is a pleasure to learn that he willed his property at Bellevue to the use of an asylum for the retirement of poor men of science, and the institution of a biennial prize of 3,000 francs, for the authors of new discoveries in electricity.

William F. Swift.

It is with deep regret that we note the death of Mr. William F. Swift, secretary of the Brush Electric Co., whose connection with that Company during the past eight years has made him so favorably and prominently known in electrical circles. Mr. Swift died at his home in Cleveland, Ohio, June 11. The following notice of his short but well-filled career is from the Cleveland *Leader and Herald* of June 12:—

"Although a young man he had had a successful career both as a newspaper man and in the business world, and the announcement of his death will be received with deep regret by a large number of friends. His death followed a long period of ill health from which, until recently, no danger was apprehended. He was a tireless worker, and the persistent energy with which he performed his duties, regardless of his health or other considerations, undermined his constitution and probably led to the development of consumption, which was the direct cause of death. Mr. Swift was born in Ravenna, on March 7, 1852. In 1867 he removed with his parents to Ashtabula, and soon afterwards began his newspaper experience by serving as correspondent of the Cleveland *Herald*. His excellent work received proper recognition in 1872 when he was given a place on the local staff of that paper. He was in a short time made city editor, and soon afterward resigned to accept a situation with the Chicago *Inter Ocean*. Six months' experience in Chicago was followed by his return to Cleveland, when he became city editor of the Sunday *Post* and was connected also with a trade journal. He could not content himself with life on weekly journals and resumed the city editorship of the *Herald* that he might again experience the rush and whirl of daily newspaper work. In 1880 he became city editor of the *Leader*, and less than a year later he accepted the offer of a position with the Brush Electric Co. He first traveled in the south and in Mexico establishing electric light plants, and upon his return to Cleveland was elected secretary of the company. He spent the winter of 1887–88 in New York, establishing an eastern office of the company, and at that time he suffered severely from throat trouble. His lungs became affected and from March to June, 1888, he was in Texas, and after a brief stay in Cleveland following his return in June he went to Sante Fe, N. M. He returned from Sante Fe a month ago, after having received assurances from the doctors there that his lungs were all right, but it was found upon his arrival in Cleveland that he was in the last stages of consumption. Mr. Swift was married to Miss Flora M. Chichester in this city on January 2, 1879, and is survived by Mrs. Swift and three children. He joined the church in Ravenna when 13 years of age, and became a member of the Euclid Avenue Congregational Church by letter when he took up his residence in the East End."

MANUFACTURING AND TRADE NOTES.

The Holtzer-Cabot Electric Co. has been incorporated under Massachusetts laws with a capital of $55,000, and this company succeeding to the business of Messrs. Holtzer and Cabot, 111 Arch street, Boston, which firm a short while since purchased the manufacturing business of Mr. A. L. Russell.

The Crocker-Wheeler Electric Motor Co. has been organized with a capital of $100,000, for the manufacture of electric motors under the patents granted Mr. F. B. Crocker, Instructor of Electrical Engineering, Columbia College, and Dr. Schuyler S. Wheeler, Expert of the Board of Electrical Control.

The Westinghouse Electric Co., have since June 1, received orders for alternating current outfit as follows:—Seattle, Wash. Ter., 750 lights; Montesano, Wash. Ter., 500 lights; Nashville, Tenn., 750 lights; Sterling, Ill., 100 lights; Butte, Mont., 750 lights; Denver, Col. (increase), 1,700 lights; New York, Safety Light, Heat and Power Co. (increase), 6,000 lights; Pottsville Pa., 1,500 lights; Texarkana, Tex., 750 lights; Kankakee, Ill., 750 lights; Mexico, Mo., 750 lights; Stapleton, Staten Island, N. Y. (increase), 750 lights.

The Thomson-Houston Electric Co., reports the following sales of stationary motors:—May 21, Thomson-Houston Electric Co., Atlanta, Ga., 7.5 h. p.; May 21, Thomson-Houston Electric Co., Chicago, Ill., 1 h. p.; May 21, Upper Appomattox Co.. Petersburg, Va., 5 h. p.; May 22, A. Harris, Providence, R. I., 1.5 h. p.; May 27, J. F. Johnson, Boston, Mass., 5 h. p.

W. Hackenthal, 21 Beekman street, has placed on the market Professor H. Aron's electric meter. This instrument is adapted for any of the commercial systems of electric lighting, and has already acquired quite a prestige in Berlin and other continental cities.

The Microphone Carbon Battery Co. has opened an office at 112 Liberty street. This company has acquired the patents and trade-mark for what is known as the "microphone" battery. Mr. George W. Fishback is secretary of the company.

The Heisler Electric Light Co., of St. Louis, Mo., have closed a contract with the Illinois Valley Electric Light and Power Co. for an electric light plant for the towns of Ottawa, Marseilles and Seneca, Ills. The station will be located at Ottawa, as the centre point of the system, from which all three of the towns will be furnished with commercial and street lights. Long-distance is one of the special claims of the Heisler system, for which reason it is said to be particularly adapted to the wants of small towns neighborly enough to co-operate in works of a quasi-public character.

The United Rubber Co., Trenton, N. J., are supplying a "Patent Rubber Mat" for type-writing machines, which has met with much success already. One of these mats has been used in the office of The Electrical Engineer for some time, much to the gratification of the type-writer operator, and to the relief of the ears of others in the office. It has a marked effect in diminishing the sharpness of the "click" of the machine.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Allegheny, Pa	Observatory Hill Pass. Ry. Co	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co	2	8	Thomson-Houston.
Ansonia, Conn	Derby Horse Ry. Co	4	1	Thomson-Houston.
Appleton, Wis	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	20	Daft.
Asheville, N. C	Asheville Street Railway	3.5	4	Sprague.
Atlantic City, N. J	Pennsylvania R. R. Co	6.5	6	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Bangor, Me	Bangor Street Railway Co	5	4	Thomson-Houston.
Binghamton, N. Y	Washington St., Asylum & Park R. R	5	8	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., Brookline Branch	11	23	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	20	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co	4	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	1.5	3	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	8	Daft.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cleveland, Ohio	East Cleveland Railroad Co.	8	16	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenport Central Street Railway Co	3.5	9	Sprague.
Danville, Va	Danville St. C. Co	2	4	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co	9	12	Van Depoele.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	10	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Eau Claire, Wis	Eau Claire St. Ry	5	6	Sprague.
Fort Gratiot, Mich	Gratiot Electric Railway	2	2	Van Depoele.
Harrisburg, Pa	East Harrisburg Pass. Ry. Co	7.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	4	Sprague.
Ithaca, N. Y	Ithaca Street Railway Co	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind	Lafayette Street Ry. Co	8	9	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angelos, Cal	Los Angelos Elec. Ry. Co.	5	4	Daft.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)	1	1	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Highland Line)	2	3	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Marlboro, Mass	Marlboro St. Ry. Co	3	2	Sprague.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3	6	Thomson-Houston
Newark, N. J	Essex Co. Pass. Ry. Co	2.5	4	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
New Orleans, La			1	Daft m'tr and Gibson st'ge battery.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co	14	14	Thomson-Houston.
Pittsburgh, Pa	Pittsburgh, Knoxville & St. Clair St. Railway	2.25	4	Daft.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Reading, Pa	East Reading R. R. Co	2	3	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Richmond, Va	The Richmond Union Pass. Railway Co	13	46	Sprague.
Salem, Mass	Naumkeag Street Ry. Co	2	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
Seattle, Wash. Ter	Seattle Electric Railway and Power Co	5	5	Thomson-Houston
St. Catherine's, Ont	St. Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	6	12	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	10	17	Sprague.
Scranton, Pa	The People's Street Ry	12	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	5	10	Thomson-Houston.
Scranton, Pa	Nayang Cross-Town Ry	1.5	3	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Southington, Conn	Southington & Plantsville Ry. Co	2	2	Thomson-Houston.
Syracuse, N. Y	Third Ward Ry. Co	4	8	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co	2.5	6	Sprague.
Stillwater, Minn	Stillwater Electric St. Ry	5	6	Sprague.
Topeka, Kan	Topeka Rapid Transit Co	17	30	Thomson-Houston.
Washington, D. C	Eckington & Soldiers' Home Electric Railway Co	3	10	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	10	Thomson-Houston.
Wichita, Kan	Riverside & Suburban Ry. Co	9	6	Thomson-Houston.
Wichita, Kan	Wichita & Suburban Ry. Co.	7.5	7	Sprague.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	3	7	Sprague. Sprague.
Wilmington, Del	Wilmington City Ry. Co	3	4	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	2	2	Van Depoele.

Total—Roads 76

" Miles 397.95

" Motor Cars.......582

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Albany, N. Y	Watervliet Turnpike & R. R. Co	15.5	16	Thomson-Houston.
Atlanta, Ga	Atlanta & Edgewood St. Ry. Co	4.5	4	Thomson-Houston.
Atlanta, Ga	Fulton Co. St. Ry. Co	9	8	Thomson-Houston.
Attleboro, Mass	No. Attleboro & Wrentham St. Ry. Co	8	5	Thomson-Houston.
Americus, Ga	Americus St. Ry. Co	5.5	4	Thomson-Houston.
Auburn, N. Y	Auburn Electric Ry. Co	3	3	Thomson-Houston.
Bay Ridge, Md	Bay Ridge Electric R. R	2	2	Sprague.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets			Bentley-Knight.
Buffalo, N. Y	Buffalo, St. Ry. Co	2.5	4	Sprague.
Cincinnati, O	Cinc. and Inclined Plane Ry	6	20	Sprague.
Cincinnati, O	Cincinnati St. Ry. Co	2.7	8	Thomson-Houston.
Cincinnati, O	Colerain Ave. Ry. Co	5	8	Thomson-Houston.
Cleveland, O	Collamer Line, East Cleveland, O	3	8	Sprague.
Decatur, Ill	Citizen's Electric St. Ry	5	4	Thomson-Houston.
Denver, Col	University Park Ry. & Electric Co	4	8	Thomson-Houston.
Dubuque, Ia	Key City Electric Ry	2	4	Sprague.
Erie, Pa	Erie City Pass. R. R. Co	12	20	Sprague.
Kansas City, Mo	Vine St. Ry		6	Thomson-Houston.
Kansas City, Mo	Metropolitan St. Ry. Co	4.5	4	Thomson-Houston.
Laredo, Texas	Laredo City R. R	4	4	Sprague.
Long Island City, N.Y.	Long Island City & Newton Electric R. R	8	2	Sprague.
Louisville, Ky	Central Pass. R. R. Co	10	10	Thomson-Houston.
Lynn, Mass	Belt Line Ry. Co		4	Thomson-Houston.
Lynn, Mass	L. & B. R. R. Myrtle St. Line	3	4	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Nahant Line)	.8	1	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Newburyport, Mass	Newburyport & Amesbury Horse Ry. Co	6	2	Thomson-Houston.
Newton, Mass	Newton Circuit Line	8	10	Thomson-Houston.
Newport, R. I	Newport St. Ry. Co	4.5	6	Thomson-Houston.
New York, N. Y	North & East River Ry. Co.	8	20	Bentley-Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	10	26	Thomson-Houston.
Omaha, Neb	Omaha Horse R. R	10	20	Sprague.
Omaha, Neb	Omaha & Council Bluffs R. R	4	2	Sprague.
Ontario, Cal	Ontario & San Antonio Heights Ry. Co	8	4	Daft.
Ottawa, Ill	Ottawa Electric St. Ry. Co	5	8	Thomson-Houston.
Peoria, Ill	Central Ry. Co	10	15	Thomson-Houston.
Pittsburgh, Pa	Federal Street & Pleasant Valley R. R	8½	25	Sprague.
Pittsburgh, Pa	Pittsburgh Suburban Rapid Transit Co		3	Daft.
Plattsmouth, Neb	Plattsmouth Electric R. R.	2	2	Sprague.
Plymouth, Mass	Plymouth & Kingston Ry. Co	4.5	3	Thomson-Houston.
Port Chester, N. Y	P. C. & Rye Beach Street Railway Co	3	5	Daft.
Portland, Oregon	Metropolitan R. R	3	4	Sprague.
Portland, Ore	Willamette Bridge Co	1.5	5	Sprague.
Quincy, Mass	Quincy St. Ry	5	4	Thomson-Houston.
Redbank, N. J	Redbank & Seabright Ry	5	3	Thomson-Houston.
Revere, Mass. (Ex.)	Revere St. Ry. Co	1.5	4	Thomson-Houston.
Richmond, Ind.	Richmond St. Ry. Co	4	6	Thomson-Houston.
Richmond, Va.	Richmond City Ry. Co.	7.5	50	Sprague.
Rochester, N. Y	Rochester Electric Ry. Co.	7	8	Thomson-Houston.
Salt Lake, Utah	Salt Lake City R. R. Co	6.5	10	Sprague.
St. Joseph, Mo	People's R. R. Co	10	20	Sprague.
St. Joseph, Mo.	Wyatt Park Ry. Co. (Northern Division)	4.5	9	Sprague.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Electric Ry	6.75	6	Sprague.
Scranton, Pa	Hillside Coal Co	1	1	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	3	10	Daft.
Spokane Falls, W. T.	Ross Park St. Ry. Co	7.50	6	Thomson-Houston.
Springfield, Mo				Fisher.
St. Louis, Mo.	Lindell Ave. R. R	5½	10	Sprague.
Sterling, Ill	Union Electric R. R	6	7	Sprague.
Tacoma, Wash. Ter	Pacific Ave. St. R. R.	6	6	Sprague.
Tacoma, Wash. Ter.	Tacoma Ave. St. Ry. Co	2	4	Sprague.
Toledo, O	Toledo Electric Ry. Co	2	2	Thomson-Houston.
Troy, N. Y	Troy & Lansingburg Street R. R.	5	6	Sprague.
Wilkesbarre, Pa	Wilkesbarre & West Side R. R	4	3	Sprague.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.
West Bay City, Mich.	West Bay City Elec. Ry. Co.	5	8	Sprague.

Total—Roads 69

Notes.

THE NATIONAL ELECTRIC TRACTION Co., Detroit, Mich., report the following roads as in operation and in process of construction:—

East Detroit & Grosse Pointe	Detroit, Mich	8 miles
Detroit City Railway, Mack Street line	" "	2 "
Citizens Street Railway	Elkhardt, Ind	7 "
Adrian Electric Railway	Adrian, Mich	3 "
Decatur Electric Street Railway	Decatur, Ill	3 "
Fort Worth City Railway Co	Fort Worth, Texas	10 "
Fort Worth Land & Street Railway Co	" "	15 "

THE ALBANY CITY COUNCIL, at its meeting of June 15th, passed an ordinance giving the right to the Watervliet Turnpike and Railroad Co. to erect poles along Broadway, from the north city line to the southern extremity of the road, for the purpose of stringing wires thereon for an electric system. The street car

company, by the terms of its charter, has the right to use any motive power desired, and several members opposed the motion on the ground that storage batteries could be used, thus avoiding the use of poles; and a communication was read from the River and Rail Electric Co. in which that company offered to equip and run a car on the road at its own expense for thirty days. A contract has been made with the Thomson-Houston company for the equipment of the road.

The petition of the Albany railway for permission to erect poles and wires in the centre of State street and its West Albany route was acted upon by the city council at its meeting, on June 24th, failing within one vote of passage. A motion to reconsider prevailed, and the petition was laid upon the table subject to future action.

ELECTRICITY APPLIED TO THE MANUFACTURE OF GAS INCANDESCENTS.

Patents No. 401,898, and 401,899, issued to Dr. Leonard Paget, April 23d, disclose an interesting application of electricity to the production of incandescents for gas lighting. We can best indicate the nature of Dr. Paget's invention by quoting from the specifications and claims of his patents. The first patent is for the process and the second for the product. The specification of patent No. 401,898, contains the following :—

My invention relates particularly to the construction of that type of incandescents in which a non-friable base or support is coated with the incandescent material; and its object is to devise an incandescent which shall have great durability.

In the prior state of the art it was old to coat with an earthy, incandescing substance, like magnesia, a non-friable base or support—such as a platinum wire—by causing the incandescing substance to adhere to the exterior surface of such base or support in several ways, which are well known and therefore need not be described here; but in all of the processes familiar to me by which the incandescing material is coated upon a base or support there is not an absolute integrality of connection between the two, by which I mean that the incandescing material does not penetrate or is not absorbed into the pores of the non friable base or support.

By the practice of my improved process I bring about an absolute integrality of connection, between the two, as I will now proceed to describe.

I take a metallic wire, preferably of steel or platinum or any metal in which there is little or no carbon, * * * and I form this wire into an incandescent hood or mantle of the desired configuration or shape, either by weaving or in any preferred manner, and I then make a solution, preferably alcoholic, of some earthy material—as, for instance, an alcoholic solution of chloride of magnesium, it being preferably a saturated solution. I then connect the ends of the incandescent or hood to an electrical generator by any preferred means, said generator having sufficient current capacity to heat the entire incandescent to a dull red temperature in air when in operation. When the metallic hood or incandescent becomes thus heated to the desired temperature, I have discovered that its surface pores expand or enlarge very materially. The heat generated by the electrical current, besides expanding the pores of the support, volatilizes the solution and causes the magnesia or oxide of magnesium held in solution to be absorbed into said pores. This process is continued until a coating of the desired thickness of the magnesia (or magnesium oxide) attaches itself to those particles which have been already absorbed and to the surface of the wire itself. The hood or incandescent is now removed from the bath and is ready for use.

I have obtained excellent results from an incandescent prepared by this process upon a platinum wire, which after the process failed to disclose to the naked eye any coating of magnesia or magnesium oxide, thus showing that the incandescing material or magnesia was absorbed into the pores of the wire.

The hood or incandescent may, if desired, be heated before immersion, and by other means than electrical, and then dipped into the solution, continuing the heating and dipping alternately until the desired coating is obtained. I prefer, however, the electrical process of heating.

I obtain by this process an incandescent in which the union between the base or support and the incandescing substance is so intimate that any difference in the co-efficients of expansion between the two prevents rupture of the incandescing material, thereby giving increased life to the incandescent produced.

I do not limit myself in the practice of this improved process to the use of chloride of magnesium, as I may, and sometimes do, use nitrate of magnesium, nitrate of aluminium, and chloride of zirconium.

The first claim is as follows :—

1. The within-described process of preparing an incandescent, which consists in causing an incandescing substance to penetrate the pores of a non-friable base or support, substantially as described.

The remaining five claims are amplifications of the fundamental invention. The specification of the second patent is substantially similar to that of the first, whilst the claims are for the gas incandescent as an article of manufacture.

REMARKABLE RECORD IN OCEAN TELEGRAPHY.

The Direct United States Cable Co. has made a new record in the time occupied in sending messages between England and New York in conveying the result of the race for the Derby stakes to the United Press in the unprecedented time of two seconds. The transmission of the news between Epsom Downs and the United Press office was continuous, that is to say, the last letter of the name of the winner had not been sent by the operator at Epsom Downs before the first letters of the name were heard in the office of the United Press in New York, so that in reality the time occupied in transmission may be said, without exaggeration, to be incomputable. The same continuous transmission was observed over the various circuits radiating from the New York offices of the United Press, whose clients throughout the country, east, south and west, were thus put in instantaneous communication with the race course at Epsom.

ELECTRICAL EXHIBITION AND SUMMER CARNIVAL AT ST. JOHN.

The summer carnival to be held at St. John, N. B., begins on the first day of July. The board of trade of St. John have the matter in hand, and a prominent feature will be made of the electrical exhibits. This department is in the hands of Mr. A. A. Knudson, of the New Brunswick Telephone Co., and he has already made arrangements for a complete display of electrical apparatus with the following: -Holmes, Booth and Haydens; Standard Underground Cable Co.; North American Photograph Co.; Western Electric Co.; Westinghouse Electric Co.; Edison Electric Lamp Co.; Julien Electric Co.; Law Telephone Co.; Jno. A. Roebling Sons Co.; Thomson-Houston Electric Co.; Simplex Electrical Co.; Bernstein Electric Co.; Holtzer and Cabot; American Electrical Works; Frank Ridlon; C. & C. Electric Motor Co.; Pettingell, Andrews & Co.; Brush Electric Co. Mr. Knudson states that he believes the exhibition will be the largest and most complete showing of electrical apparatus ever held on the continent. A portion of the apparatus will be kept in operation for the instruction and entertainment of visitors.

THE TELEPHONE.

THE United States Circuit Court at Boston, was called upon, the 1st of June, to consider another point in the bill in equity to cancel the Bell telephone patent on the ground of prior invention by Reis, of Germany, by Gray, by Drawbaugh and others, also on the ground of fraud by Bell in the patent office. The Bell company originally demurred on the ground of no authority by the United States to bring suit. The Supreme Court overruled this demurrer and ordered the company to answer. They answered and filed a plea. The United States filed replication. Now the United States asks that an examiner be appointed to take the proofs, and the Bell company asks the Court to restrict proofs to the fraud issue, on the ground that many of the other grounds for the repeal of the patent set up in the bill are before the Circuit Court in other cases.

LEGAL NOTES.

THE TERM OF THE DOMESTIC PATENT LIMITED IN ALL CASES BY THE TERMINATION OF A PRIOR FOREIGN GRANT.

A question of considerable importance was decided on May 25th, in the U. S. Circuit Court of the Eastern District of Missouri, by Justice Thayer, in the case of *Huber* vs. *Nelson Manufacturing Co.* It appeared that a patent had been secured in England in 1874, which became void by the failure of the patentees to pay the stamp duty. Subsequently, an application was filed for a patent in the United States for the same invention, which was granted in due course; and it was upon this patent that the suit was brought.

The Court holds that the power of the commissioner of patents is so limited by section 4,887 of the revised statutes that he cannot lawfully issue an American patent for a term to extend beyond the existence of a prior foreign patent; and, if such patent is issued after the foreign patent for the same invention has become void for non-payment of stamp duties, it is without authority of law, and void.

It is somewhat singular that this precise question has never before reached our courts for decision. In the opinion a number of well-known circuit court decisions were referred to, which were based in substance upon the theory that every American patent ought to run for a definite period, ascertainable as soon as the patent issues, and that Congress could not have intended, by section 4,887, that patents should be granted for an uncertain period. In the opinion of the Court, the Supreme Court has clearly discarded this doctrine by holding, as it did in the Bate case, recently discussed in these columns, that the duration of the American patent is dependent upon circumstances that affect the duration of the foreign monopoly. "The arguments used in the course of that decision," says the Court, "lead logically to the conclusion that United States letters patent issued subject to the provisions of section 4,887 remain in force no longer than the foreign patent having the shortest term; that the life of the domestic patent is measured by the actual duration of the foreign patent, and may be abridged, as well as lengthened, by circumstances which operate under the foreign law to abridge or lengthen the foreign monopoly." The last clause of the section presupposes that there is a foreign patent in force when the American patent issues, the actual existence of which foreign patent is to determine the duration of the domestic patent. In conclusion, the Court says: "If there is no such foreign patent in force when the American patent issues, but a foreign patent has been theretofore granted for the invention, and it has lapsed and become void, there is no authority in law, in my opinion, for the American grant. The result is that the patent is adjudged to be void."

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From May 21, to June 11, 1889 (inclusive).

Alarms and Signals:—*Thermostat*, C. F. Hilkier, 403,937. *Push-Button*, H. L. Currier, 404,033, *Electric Signaling Apparatus*, J. P. Coleman, 404,170 *Fire and Police Signaling Apparatus*, A. C. Robbins, 404,226, May 28. *Non-Interfering Fire-Alarm Signal Box*, J. J. Ruddick, 404,438. *Fire-Alarm Telegraph*, S. A. Chase, 404,518. *Duplex Fire-Telegraph*, same, 404,519, June 4. *Electric Signal for Engine-Shafts*, J. C. Ricketson, 404,866. *Electric Indicator for Engine Shafts*, same, 404,867. *Municipal Signal Apparatus*, J. C. Wilson, 405,235, June 11.

Clocks:—*Electric Self-Winding Clock*, J. H. Gerry, 405,089. *Electric Alarm Clock*, W. E. Hadlock, 404,906. *Electric Alarm Clock*, B. Dubinski, 405,206, June 11.

Conductors, Conduits and Insulators:—*Insulator*, J. C. Berrang, 403,727. *Underground Conduit for Electrical Conductors*, C. B. Cole, 403,825, May 21. *Pole for Electric Wires*, U. Snead, 404,232, May 28. *Electric Cable Terminal*, R. H. Widdicombe, 404,818, June 4. *Underground Conductor*, G. E. Tailleur, 404,877. *Insulated Electrical Wire*, H. W. Johns, Jr., 404,913, June 11.

Distribution:—*Electrical Converter*, H. Lemp, 403,511, May 21. *Electric Converter-Box*, A. Schmid, 404,114. *System of Electrical Distribution*, G. Westinghouse, Jr., 404,139, May 28. *Method of Distribution by Alternating Electric Currents*, O. B. Shallenberger, 404,566. *System of Generators for Alternating Electric Currents*, same, 404,567, June 4. *Electrical Distribution System*, T. A. Edison, 404,902. *Method of Distributing Electricity by Secondary Batteries*, W. W. Griscom, 404,968, June 11.

Dynamos and Motors:—*Dynamo-Electric Machine*, T. L. Willson, 403,630; A. I. Gravier, 403,836, May 21. *Commutator*, H. H. Blades, 403,905. *Electric Motor*, W. S. Belding, 404,067. *Dynamo*, same, 404,068. *Clamp for Electric Motors*, same, 404,069. *Regulating Self-Exciting Alternate Current Electric Generators*, W. Stanley, Jr., 404,120. *Electro-Dynamic Motor*, C. J. Van Depoele, 404,324, May 28. *Electric Motor*, C. S. Bradley, 404,465. *Alternating Current Electric Motor*, same, 404,466. *Dynamo-Electric Machine*, W. Hochhausen, 404,484. *Electric Motor and Regulator*, A. Gartner, 404,533. *Regulator for Dynamo-Electric Machines*, E. P. Clark, 404,602. *Safety Attachment for Electric Motors*, W. S. Paca, 404,651. *Electric Motor*, H. B. Slater, 404,661. *Detachable Brush-Holder for Dynamos*, J. F. Kester, 404,712. *Armature-Core for Dynamos*, same, 404,713. *Regulator for Dynamo-Electric Machines or Motors*, same, 404,714. *Brush Spring for Dynamos*, 404,715. *Regulator for Electric Motors*, A. Gartner, 404,783, June 4. *Regulation of Alternating Electric-Current Generators*, G. Pfannkuche, 404,859. *Brush-Holder for Dynamos*, W. S. Bishop, 405,002. *Regulation of Alternating Electrical Current Generators*, G. Pfannkuche, 405,174. *Dynamo-Electric Machine*, O. P. Loomis, 405,218. *Electric Motor Starting and Stopping Device*, F. A. Perret, 405,223, June 11.

Galvanic Batteries:—*Galvanic Battery*, J. C. Vetter, 403,802; D. J. Arnold, 403,868, May 21. *Porous Cup for Batteries*, C. B. Noble, 403,955, May 28. *Galvanic Battery*, W. Frishmuth, 404,699, June 4. *Galvanic Battery*, J. A. Barrett, 405,196, June 11.

Ignition:—*Electric Gas-Lighter*, J. H. Lehman, 403,944, May 28. *Automatic Gas Lighting and Extinguishing Apparatus*, N. H. Shaw, 405,126, June 11.

Lamps and Appurtenances:—*Arc Lamp*, D. Houghton, 403,671, May 21. *Automatic Cut-Out for Electric Lamps*, E. R. Knowles, 403,941. *Arc Lamp*, W. L. Silvey, 403,964. *Apparatus for Treating Filaments*, F. S. Smith, 404,118. *Arc Lamp*, La M. C. Atwood, 404,214. *Electric Arc Lamp*, same, 404,245, J. R. Fox, 404,351, May 28. *Submarine Search Light*, A. L. Dutton, 404,390. *Filament for Incandescent Electric Lamps*, T. D. Bottom, 404,463. *Portable Electric Lantern*, W. Frishmuth, 404,698, June 4. *Incandescent Lamp*, C. A. Backstrom, 404,816. *Manufacture of Filaments for Electric Lamps*, H. S. Maxim, 405,170. *Apparatus for the Manufacture of Filaments for Incandescent Lamps*, same, 405,239, June 11.

Measurement:—*Electric Meter*, R. P. Sellon, 404,310, May 28. *Voltmeter*, L. Daft, 404,470. *Electric Meter for Alternate Currents*, M. M. M. Slattery, 404,801, June 4. *Apparatus for Indicating the Strength of the Current in an Electric Circuit*, G. Pfannkuche, 404,860. *Method of Indicating the Strength of the Current in an Electric Circuit*, same, 404,861, June 11.

Medical and Surgical:—*Electrode for Electro-Therapeutic Body-Wear*, H. P. Pratt, 405,176, June 11.

Metallurgical:—*Machine for Separating Iron from Ores*, G. Conkling, 403,575. *Method of Operating Electric Furnaces*, J. C. Hobbs, 403,752. *Magnetic Separator*, G. Conkling, 403,576. *Magnetic Ore-Separator*, W. R. Thomas, 403,624, May 21. *Method of Rendering Nickel and Nickel Alloys Non-Magnetic*, H. Ostermann and C. Laeroix, 404,220. *Process of Separating Ores by Magnetism*, C. M. Ball and S. Norton, 404,332. *Magnetic Ore Separator*, same, 404,333. *Process of Separating Ores*, same, 404,334, May 28. *Electric Drilling Machine*, E. A. Sperry, 405,187. *Electric Mining Machine*, same, 405,188, June 11.

Metal Working:—*Process of Electric Soldering, Brazing and Welding*, E. Thomson, 403,707. *Method of Electric Welding and Brazing*, same, 403,708, May 21. *Process of Electric Riveting*, E. E. Ries, 404,306, May 28. *Determining the Temper of Iron or Steel*, C. A. Caspersson, 404,600, June 4.

Miscellaneous:—*Electro-Magnet and Armature*, F. W. Cole, 403,517. *Means for Operating Draw-Bridge Spans by Electricity*, J. M. Orford, 403,549. *Plastic Compound for Use in Various Arts*, A. T. Woodward, 403,631. *Electrical Switch for Elevators*, W. E. Nickerson, 403,691, May 21. *Apparatus for Automatically Regulating Temperature of Steam Generating Tubes*, T. L. Sturtevant, 403,972. *Electrical Switch for Elevators*, W. E. Nickerson, 404,015. *Automatic Circuit-Interrupter for Electric Circuits*, A. L. Reinmann and P. Lange, 404,112. *Lightning Arrester*, R. Belfield, 404,154. *Electrical Switch for Elevators*, W. E. Nickerson, 404,221. *Electrical Apparatus for Controlling Elevators*, R. F. McFeely, 404,361, May 28. *Unison Device*, G. F. Oehmen, 404,426. *Induction Coil*, J. F. Kelly, 404,630. *Firemen's Electric Wire Cutter*, D. A. Woodhouse and T. V. Forster, 404,667. *Apparatus for Purifying and Ageing Liquors*, S. G. Cabell, 404,682. *Method of Filling Teeth*, E. C. Taylor, 404,745, June 4. *Induction Coil*, F. H. Brown, 404,822. *Elevating Machine*, J. E. Byrne, 404,893. *Electrically-Controlled Engine*, J. E. Byrne, 404,894. *Electric Elevating-Machine*, same, 404,895. *Electrically-Controlled Engine*, same, 405,010. *Magnetic Machine for Removing Mineral Substances from Grain*, M. L. Mowrer, 405,045. *Discharge Device for Electrical Machines*, A. Schmid, 405,124. *Electric Temperature-Regulator*, L. F. Easton, 405,151. *Electro-Magnetic Transmitter*, J. T. Williams, 405,194, June 11.

Railways and Appliances:—*Railway Signal*, T. A. Casey, 403,515. *Switch-Instrument for Railroad Signals*, G. C. Steenbergh, 403,619. *Electric Railway*, R. M. Hunter, 403,754; F. M. Speed, 403,786. *Slotted Conduit for Electric Conductors*, C. J. Van Depoele, 403,800. *Electric Railway*, same, 403,801, May 21. *Trolley for Electric Railways*, T. Streat, 403,969. *Trolley for Electrical Railways*, D. A. Ainslie, 404,149. *Closed Slotted Conduit*, C. J. Van Depoele, 404,325, May 28. *Motive Mechanism for Railway-Cars*, H. F. and G. F. Shaw, 404,441. *Railway-Signal*, A. J. Wisner, 404,457. *Electric Railway*, W. Cannell, 404,469. *Track Moistening Apparatus for Electric Railways*, E. D. Priest, 404,559. *Electric Railroad*, L. Daft, 404,687, June 4. *Electric Railway*, S. H. Short, 404,873. *Alarm-Signal for Cable and Electric Railway Cars*, L. Pfingst and S. A. Bemis, 404,981, June 11.

Secondary Batteries:—*Secondary Battery*, A. Jamieson, 403,593, May 21; J. B. Price, 403,957; H. F. DeB. Cameron and T. Harris, 404,168, May 28; T. H. Hicks, 405,213, June 11.

Telegraphs:—*Telegraph-Sounder*, F. L. Van Epps, 403,626, May 21. *Telegraph* J. Burry, 404,165, May 28. *Telegraph Apparatus*, E. B. Shafer, 404,507, June 4. *Quadruplex Telegraphy*, C. D. Haskins, 405,211, June 11.

Telephones and Apparatus:—*Mechanical Telephone*, W. W. Nichols, 403,547. *Individual Call and Switch*, E. Pope, 403,776, May 21. *Telephone Transmitter*, E. S. Drake, 404,471. *Telephone Support*, C. W. Brown, 404,680, June 4. *Method of Recording and Reproducing Articulate Speech or other Sounds*, G. W. Littlehales, 404,850. *Testing Apparatus Switch-Boards*, W. E. McKivitt, 405,221, June 11.

EXPIRING PATENTS.

Patents relating to Electricity which becomes Public Property in July 1889.

Reported for the ELECTRICAL ENGINEER, *by* F. B. Brock, *Patent Attorney*, 639 *F street, Washington, D. C.*

Indicator, W. H. Mumler, 128,500; *Printing Telegraph*, 128,604-5-6-7 and 8; *Annunciator*, R. May, 128,552; *Lightning Rod*, J. W. Hankenson, 128,617; *Printing Telegraph*, J. P. Humaston, 128,627; *Battery*, J. A. Robbins, 128,660; *Fire Telegraph*, Rosenbusch & Kreitz, 128,662; *Burglar Alarm*, A. O. Wilcox, 128,691; *Dial Telegraph*, S. Chester, 128,708; *Lightning Rod*, J. C. Schoonmaker, 128,818; *Relay and Sounder*, G. Little, 128,894; *Igniting Explosive Charge*, C. A. and I. S. Browne, 128,945; *Motor*, J. S. Camacho, 129,000; *Regulator*, V. Barjon, 129,085; *Electrolysis Apparatus*, A. S. Freeman, 129,124; *Battery*, C. A. Linke, 129,148; *Electrolysis Apparatus*, L. Brandeis, 129,207; *Printing Telegraph*, Foote & Randall, 129,219, M. Gally, 129,331, J. S. Brown, 129,391; *Railway Signal*, Hendrickson & Pope, 129,408, F. L. Pope, 129,425; *Battery*, A. G. Davis, 129,465; *Transmitter*, E. A. Callahan, 129,526; *Circuit Closer*, J. E. Smith, 129,607; *Printing Telegraph*, G. Landers, 129,641; *Lightning Rods*, D. Munson, 129,675-6-7, J. Robertson, 129,683; *Printing Telegraph*, M. Gally, 129,725; *Induction Coil*, R. Sayer, 129,752; *Automatic Telegraphs*, G. Little, 129,839-40; *Motor*, W. H. Odell, 129,857; *Conductor*, J. Olmstead, 129,858; *Circuit Closer*, J. E. Smith, 129,867; *Electrolysis Apparatus*, G. W. Beardlee, 129,881; *Therapeutic Body Wear*, W. H. Gordon, 129,945; *Therapeutic Bath*, J. A. Hoffman, 129,561; *Relay and Sounder*, Hicks & Shawk, 130,048.

[Drawings and specifications of any patent will be furnished by Mr. Brock at cost, 15 cents each.]

THE

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VOL. VIII. NEW YORK, AUGUST, 1889. No. 92.

SOME INSIDE HISTORY.

THE testimony taken in the legal inquiry which has been going on in this city during the past month in respect to the capacity of electricity to produce certain, instantaneous and painless death, has unearthed quite a number of interesting, not to say peculiar facts. We learn from his own testimony that the eminent philanthropist to whom the people of the State of New York appear to be principally indebted for the electrical execution law which now disgraces its statute book, had, at the time it was enacted, "merely a general knowledge,"—notion would have been a better word—"that when men took hold of electric light wires, they were killed." Continuing, he said :—

> *I favored it principally because Mr. Edison did.* I consider him the greatest electrician of modern times, and after he had answered two questions I asked of him, I was satisfied.

It is not difficult for one acquainted with the vein of sardonic humor characteristic of the justly distinguished inventor, to picture to himself the bland and urbane smile which overspread the countenance of that gentleman as his admiring disciple was informed that electricity was just the thing, and moreover that by a fortunate coincidence the alternating current apparatus made and sold by his most troublesome commercial competitor was precisely the means best adapted to administer it.

The Medico-Legal Society then took up the subject, with the assistance of Harold P. Brown, who mysteriously appeared about this time,—as the man is always said to do when the occasion calls for him,—and undertook an experimental investigation. "To my surprise," says Mr. Brown, "Mr. Edison at once invited me to make the necessary experiments at his private laboratory, and placed all necessary apparatus at my disposal." A further cause for surprise may appear in the fact that "Dr. A. E. Kennelly, Mr. Edison's chief electrician" took a leading part in the experiments. Many unfortunate dogs and other animals were tortured to death by Messrs. Brown and Kennelly, such of them as could not be killed by electricity being, as one of the spectators testified, despatched by a blow on the head with a brick. The outcome of this investigation was a "report" from the learned committee of medico-legalists having the matter in charge—in which their intelligent comprehension of the subject was strikingly revealed by a remark to the effect that the larger the surface of the electrode applied to the body, the *greater* the resistance—recommending that a dynamo should be employed for the execution of criminals "*capable of generating an electro-motive force of at least* 3,000 *volts*, and a current used with a potential between 1,000 and 1,500 volts, according to the resistance of the criminal." This important point having been settled, Mr. Brown undertook to supply the authorities with the required apparatus. Instead of taking the usual course of advertising for proposals to furnish dynamos of the capacity recommended by the medico-legal committee, of which any number might have been had in open market, he publicly announced that he proposed to use the Westinghouse dynamo and no other, although the maximum capacity of this machine is only 1,050 volts, instead of 3,000, and its rate of alternation only 275 instead of a minimum of 300, as called for by the report. Through the kind offices of a rival corporation,—itself engaged in the sale of a machine which would have much more nearly fulfilled the requirements,—three alleged Westinghouse dynamos were obtained, and, as was triumphantly announced in the newspapers, "Mr. Brown had the numbers which were stamped on the dynamos by the manufacturers carefully obliterated, so that even when they are put up in the prisons it will be pretty difficult for the manufacturers to find out how they were purchased." Truly a dignified business for a great commonwealth to be engaged in (!)

Returning to the results of the inquiry, the net outcome of the evidence seems to be this ; that the effect upon a human being of a powerful electric current is one which is impossible to be predicted in any particular case. As a means of legal execution it might not inaptly be compared to throwing a man from a five-story house; it will probably kill him; it will almost certainly inflict fearful injuries upon him ; but then again he may possibly escape, as many have done, almost without injury.

The naive confession made in the witness chair by the putative author of the act, that his only reason for favoring execution by electricity was "because Mr. Edison did," ought, we should suppose, to be enough to ensure its instant repeal as soon as the next legislature assembles.

PATENTS ON ALTERNATE CURRENT DISTRIBUTION.

IN the spring of 1887, a suit was brought in the U. S. Circuit Court in Massachusetts, by the Westinghouse Electric Co. against the Sun Electric Co., of Woburn, alleging infringement of the Gaulard & Gibbs patent for electrical

distribution by alternating currents and reducing converters. While the testimony was being taken, and before the case came to be heard in court, the Fort Wayne Jenney Co. became interested in the defense, which was thereafter conducted mainly by their counsel.

At the trial of the case which took place before Justice Colt, in Boston, in February, 1888, Judge Taylor, for the defense took, the ground that inasmuch as the apparatus for the distribution of electricity made and sold by the Sun company comprised a high tension alternating dynamo, two main conductors, and converters arranged in multiple-arc and not in series, it did not infringe the patent of Gaulard & Gibbs. In his brief he said :—

To take the series system as exemplified in all the plants constructed by Gaulard & Gibbs, and rearrange its parts, and make out of them the multiple system exhibited in Slattery's Boston plant involves *invention of transcendent merit*. It is the discovery of a hidden force in nature, and the utilization of it for the production of *the most magnificent results*. This invention never so much as entered the minds of Gaulard & Gibbs. To them counter E. M. F. was a mysterious, obstinate, ruinous impediment in the way. They knew of no method of dealing with it except to minimize it by the use of super-saturated cores at enormous loss of efficiency, and then overcome what was left of it by main strength from the dynamo. In Slattery's hands it became the supervising intelligence which pervades the apparatus, distributes the current with exact apportionment among the thousand lamps of the system, returns all that is not needed, and economizes expenditure like a faithful steward.

In his oral argument he contended that the plant used by the defendant, now known as the Slattery or Fort Wayne Jenney apparatus, embodied "an invention of the grandest kind." He went on to say :—

But the invention would not consist merely in suggesting that these should be put in multiple arc. The invention must go further than that. Everybody knew that things could be put in series and multiple arc. The invention lay, more particularly than in anything else, *in discovering a law of induction; in discovering the fact that a sub-saturated core, by the creation of counter electromotive force furnishes a means of perfect regulation*. The invention lay in the utilization of a return current in the converters. That is a thing Gaulard & Gibbs never thought of. The thing they proposed to do was to override the return currents by force. *The thing to do was to utilize them and make them do the perfect work of regulation.*

It is possible that Judge Taylor might have extolled this beautiful invention with somewhat less exuberance of eloquence, had he known at the time that like the Gaulard & Gibbs' patent, it had become the property of the Westinghouse Electric Co., by honorable purchase from the original inventor. But he certainly succeeded in his intention of convincing the Court that the real invention lay in the method of regulation, inasmuch as Judge Colt in his opinion held that Gaulard & Gibbs must be limited to the series arrangement, and that therefore the defendants, who used the multiple-arc arrangement, did not infringe the patent.

But it now appears that the last word in this controversy had not been said. The discovery of the important fact that converters having a high co-efficient of self-induction, when placed in parallel and supplied with an alternating current, may be made practically self-regulating, is generally admitted to have been first made by Kennedy, of Glasgow, as early as the spring of 1883, and published by him at the time. Kennedy's rights in the United States, as it now appears, were long since purchased by the Westinghouse company, and a patent upon this method of self-regulation without reference to the particular apparatus used, has recently been issued. The principle covered by this patent is apparently in all respects as fundamental and important in alternate current distribution as that of Bell has proved to be in telephony, and must necessarily become an exceedingly important factor in the future development of incandescent lighting.

A VERY CIVIL WAR.

War against the telegraph poles has been started by the board of freeholders of Union County, N. J.,—at least against all such telegraph and telephone poles as interfere with proposed improvements of the county roads. The freeholders evidently mean business, for they have served notice on the companies that unless the poles are removed they will be taken down at the expense of the county. This is the first action of the sort instituted in any country district, if we are not mistaken. It seems to foretell the ultimate doom of the telegraph pole everywhere. Putting the wires underground in the open country would be a simple and not very costly matter, and the companies will probably find it to their interest to stop putting up poles, even if they do not begin at once the removal of those already in use.

The foregoing extract from a recent number of the N. Y. *Tribune*, is a fair sample of the tone which a certain portion of the press feels called upon to adopt whenever it has occasion to speak of telegraph, telephone and electric lighting enterprises. No effort is spared by these journals to excite prejudice against such undertakings, and to lead everybody to regard their owners as public enemies who deserve not the slightest consideration, not even the courtesy of a hearing. In the particular case above cited, the facts are, that the county engineer, after making preliminary surveys for paving certain roads to a prescribed breadth, reported that in a few instances the poles were standing in the way of the proposed improvement, whereupon the county authorities, in a perfectly courteous communication, notified the telegraph company to remove them. The same thing has occurred hundreds of times everywhere, and would seem to call for no special remark. One would suppose that the telegraph company was expected to defy the authorities, and defend its position with grape and canister, alternating currents or other deadly influences. Why people who invest their money in electrical enterprises should so frequently be treated like outlaws, and their property destroyed and their earnings confiscated, wherever possible, is one of the things we should be glad to have explained.

Just at the present time an area of legal disturbance appears to prevail over a considerable portion of the country, at least, so far as electrical interests are concerned. while the indications are that a local storm-centre of considerable magnitude and intensity is developing directly over the Thomson-Houston Electric Co. As will appear, by reference to our legal notes, among the numerous suits which this company has recently found itself called upon to defend, are some which are of vital importance to its interests, notably those instituted by the Edison company and the Westinghouse company, one alleging infringement of the three-wire system and the other of the alternating system of central station distribution. As every one of the four hundred and odd central stations now in operation in the United States have found it indispensably necessary to make use of one or the other of these systems, and as the Thomson-Houston company is using both of them, the consequences of an ultimate injunction may be highly in-

convenient, to say the least. The United States company is pushing its suit against the Thomson-Houston on the Weston sectional armature patent, which involves a construction used in all its dynamos and motors; the Sprague company has commenced a suit on the spring suspended motor for electric railway cars, patented by Sprague and used by the Thomson-Houston in its larger railway plants, and if our recollection is right the Brush company are also claiming certain infringements in arc-lighting devices. Taking it all in all, there would seem to be a prospect of a rather lively season; for any one acquainted with the way things are usually done by the Thomson-Houston combination will feel justified in predicting that the contest is not likely to be a "walk over" for the attacking parties, whatever may be its ultimate outcome.

However far or fast the Portelectric Co., recently noticed in The Electrical Engineer, may transport parcels or people, reports of its sanguine expectations have reached a long distance already. The following is from the *Electrical Review*, of London. We are sorry to see the title of the company spoiled by *Post*:—

230 Miles per Hour.—A New York correspondent says that the latest invention for rapid transportation of mails is being introduced by the Post Electric Co. It consists of an elevated railway track of a new design, for a car made of magnetized steel and running upon a single rail. It has been exhibited in Boston, and explained by Professor A. E. Dolbear, of Tufts College, who announced that, after a very thorough examination and testing of the discovery, he was certain that a car could be run from New York to Boston, a distance of some 230 miles, in one hour. He explained that while the new plan will at first be devoted to letter carrying, and by it there can be a mail from city to city several times every forenoon, afternoon and evening, it will be entirely possible to carry people as well as the mails, and that this will before very long be done. We are surprised that a man of Professor Dolbear's standing should countenance this preposterous notion.

The benevolent efforts that the promoters of some recent electrical enterprises are making to distribute their shares in small amounts throughout the country, by offering them to everybody who has a dollar or two within reach, suggests the query whether they may not be working, indirectly and modestly, in the cause of the Anti-Poverty Society; why else should they go to so much pains to share their future profits so widely?

Here are Allen M. Pennock, Chattanooga, Tennessee; M. Child, Jr., Sherman House, Chicago, and Geo. B. Pennock, inventor and electrical expert, Chicago, offering, broadcast, shares at from 25 cents to $2.00 in a series of "Pennock Battery" companies, exploiting "The Cheapest and Brightest Electric Light in the World. No Steam Boilers, No Engines, No Dynamos. Successful Plants now in Operation and being erected in all parts of the U. S. Combined Capital $2,275,000."

This is just the sort of thing that the world is anxiously looking for, and if the Pennocks will forego their philanthropy and exhibit one or two of the "successful plants now in operation" to a few intelligent capitalists they will do the community a better service by getting "The Cheapest and Brightest Electric Light in the World" into general use at an early day.

Preliminary measures for a World's Fair in New York, in 1892 have gone so far, under the leadership of Mayor Grant, that there is no longer any doubt that the undertaking will have the energetic support of the people. It is reasonable to expect a most successful exhibition.

The electrical department ought to be, and doubtless will be, far and away the most extensive and comprehensive exhibition of industrial electricity ever held.

Mr. Park Benjamin—a part of whose letter in the *N. Y. Herald*, of July 28, we reprint elsewhere—while, apparently, not opposed to executions by electricity, has obviously clearly discerned the influences at work in the inception and promotion of the proceedings following the adoption of Mr. Gerry's act by the legislature.

OBSERVATIONS.

It is apparently quite as easy to perpetuate fiction in electrical history, as in the history of the world. The fallacy of the Romagnosi claim to the discovery of electro-magnetism has been fully proved by the Electrical Engineer, by Fahie's History of the Early Telegraphs, and by others; yet it has as many lives as a cat, and turned up only a little while ago before the observer, as fresh as ever.

The last specimen of this kind is the deformed model of Bell's Centennial Receiver.

This (the real receiver, not the deformed one), as some of our readers may know, was a simple tubular magnet;—an electro-magnet with solid iron core, and cased outside the coils with a soft iron tube, the tube and core being united by a disc-formed heel-piece. The tube at the upper end was a trifle longer than the core.

The diaphragm was a disc of soft iron lying flat on the edge of the tube, but not touched by the core. It was not fixed at all. This was the telephone receiver which talked to Sir Wm. Thomson and the Emperor of Brazil at the Centennial Exhibition. Hence its name.

But hereby hangs a tale. Mr. Bell presented Sir William Thomson with a set of these primitive telephones; and Sir William essaying to show them in public on his return to England, could not get them to work; and because he failed to make them work, the Bell patent was not fully sustained by the courts in England.

Engineering gave a well written account of Sir William's lecture, illustrated by various pictures. The picture of the receiver showed, however, an instrument essentially different from the same instrument as used at the Centennial. The anglicized receiver embodied the tubular magnet, but instead of the flat unfixed disc diaphragm, there appeared a disc, fastened at one point near its edge by a screw to the edge of the surrounding iron case of the magnet; and having its opposite edge cocked up, making it look indeed as if it could talk as well as a phonographic doll, but quite incapacitating it from doing so.

Upon investigation it appeared that the diaphragm being loose, Mr. Bell feared that it would be lost, and therefore before handing it to Sir William, he had a workman affix it by a small screw to the edge of the magnet, simply to keep the two parts together.

He either forgot to tell Sir William this, or Sir William having been told forgot it. In transit over the Atlantic, it also appeared that the free edge of the disc so fastened, somehow became bent up into the form, in which it is shown in the picture.

And this is the reason that the instrument refused to work for Sir William; being fastened at one edge by a screw, and bent away from the magnet at the other, its feelings were clearly too full for utterance.

Yet the picture of the ill-treated receiver, with its screwed up and bent diaphragm has been copied into nearly every book ever written about the telephone, appears upon the pages of the very last book relating to that subject; and without doubt will continue to usurp the place of the real Centennial Receiver in every illustrated story of the telephone, till time shall be no more.

ARTICLES.

THE BRUSH ELECTRIC COMPANY'S NEW ALTERNATING CURRENT SYSTEM.

Mr. Charles F. Brush, and the company whose name and business are identified with his talents and skill, have been engaged for a considerable period in developing a system of long-distance distribution of electrical energy by means of alternate currents and transformers. They have now reached a point at which they are satisfied with the efficiency and simplicity of the apparatus employed to this end—qualities that are always the marks of genius. Their system, a description of which is given herewith, possesses many features of novelty and interest. The end attained has been reached by a bold abandonment of long traversed routes already familiar to the public. The underlying principle of the remarkable "coreless" dynamo here illustrated, was discovered and applied by Mr. Brush more than 10 years ago, and new demands have now called for its extended application on a larger scale.

The alternating dynamo (figure 1), is novel, compact, simple, symmetrical and strong. Its field magnets are many and carried by the shaft; the armature is fixed and absolutely free from any magnetic material; its parts are easily accessible. An armature coil may be cut out, removed or replaced without stopping the machine.

The machine chosen for illustration and description has an output of 60,000 watts; it supplies current for a thousand 16 c. p. lamps.

The shaft bearings, bearing standards, base plate and armature slides are cast in one solid piece of graceful form and ample strength. The centre line of the shaft is $16\frac{11}{16}$ inches above the surface of the base plate, high enough for access to all parts of the dynamo and low enough for steadiness and freedom from strain on foundations. The four inch steel shaft (tapering to $3\frac{1}{2}$ inches in the bearings) carries two heavy cast-iron yoke-pieces, 27 inches in diameter. To each of these are screwed, at equal radial and circumferential distances, the wrought iron cores of 12 magnets of alternating polarity. The two yoke-pieces, with their bolts, washers, etc., weigh about 950 pounds; the magnet cores, 380 pounds; the magnet wire, 400 pounds. Thus the whole rotating mass of cast-iron, wrought-iron and copper, acts as a fly wheel weighing more than 1,700 pounds, and tending to neutralize any variation in the speed of the prime generator. As the nominal speed of the machine is fewer than 1,100 revolutions per minute, the structural strength is more than sufficient to meet all demands made by centrifugal force. Further than this, the mechanical stress is less when the magnets are excited

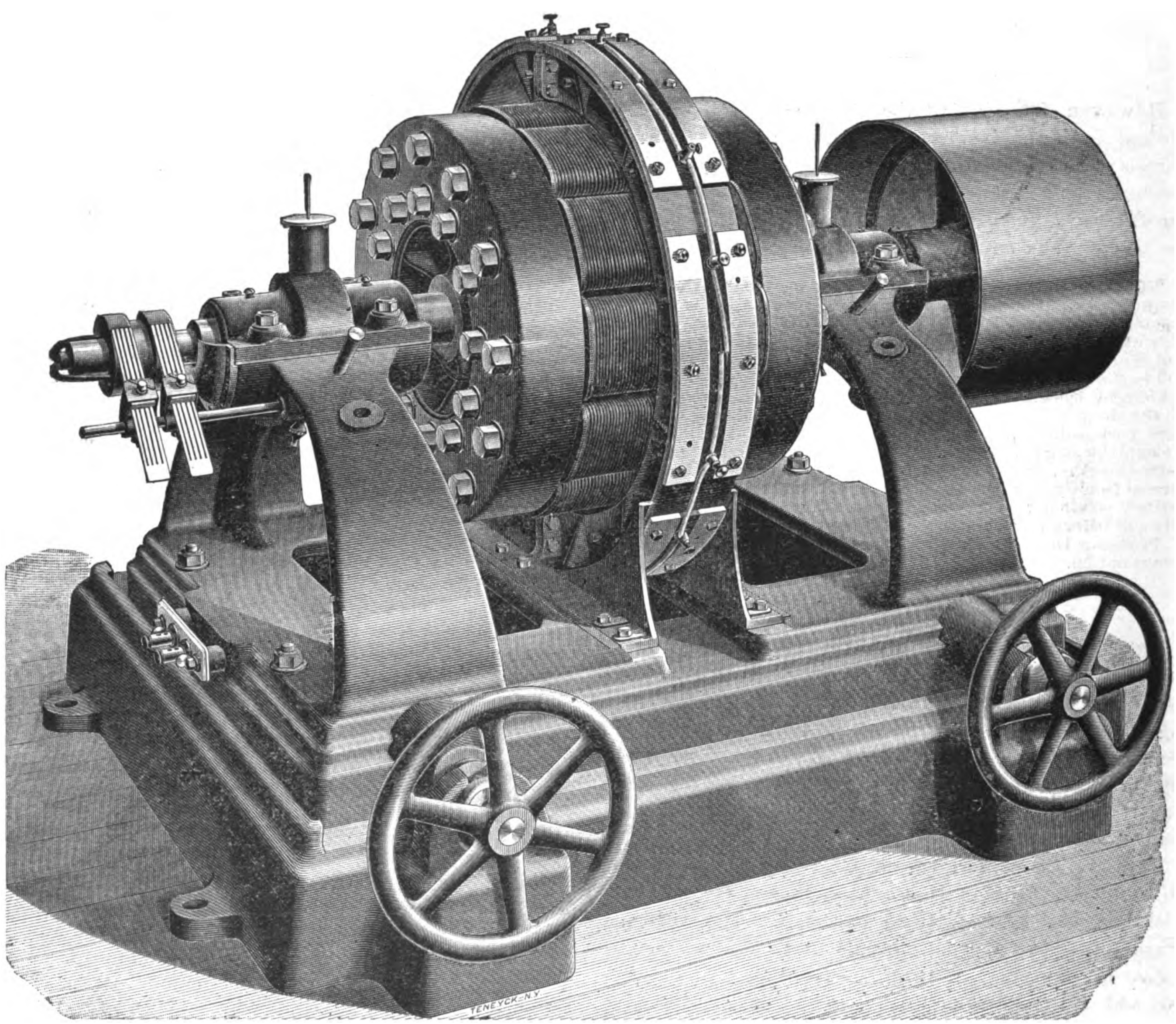


Fig. 1.—Brush Alternating Current Dynamo.

than when the dynamo is running without load, inasmuch as the lines of magnetic force, between the faces of opposing poles, tend to counteract centrifugal force. In machines of larger size, as usual, the speed is less; that of the 150,000 watt dynamo being not more than 700 revolutions per minute. This larger alternator is driven by two belts and carries a pulley at each end of its shaft. The great advantage of low shaft speed will be appreciated by every mechanic who has a due regard for depreciation of apparatus and cost of oil, attendance, trouble and repairs.

The pulley has a 14-inch face. As it overhangs, the belt may be run to countershafting overhead or below. The shaft-bearing at the pulley end has 14 inches wearing surface and the bearing at the other end, 12 inches.

But the most interesting part of the alternator is the fixed armature, shown in figure 2. The vertical disc is

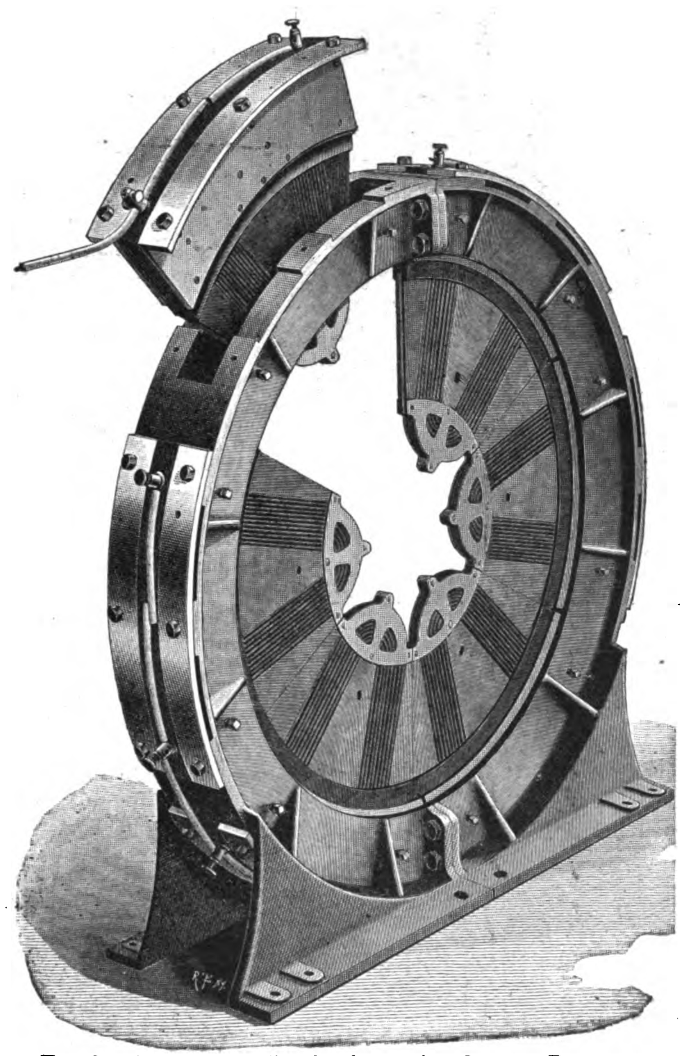


FIG. 2.—Armature of Brush Alternating Current Dynamo.

provided by flat armature coils, made of insulated copper ribbon wound on porcelain cores. The copper ribbon of each coil is re-inforced on either side with strong insulating material of the same thickness as the porcelain. One of these re-inforcements is grooved and the other tongued. Each coil, consisting thus of core, ribbon and re-inforcements, has an angular width of 60 degrees. The upper part of each face of each coil is covered with an insulating plate five-sixteenths of an inch thick. The coil thus built up and insulated is set in german-silver holders, cut from true turned rings and held together by sunk-headed screws, as shown in figure 2. Each terminal of the copper ribbon connects with a binding post, as shown.

The six armature coils thus mounted, are carried in a german-silver frame consisting of two semi-circles bolted together on the line of the vertical diameter. The cross-section of this ring frame is girder-like. The six mounted armature coils slip into the slots of the frame. The tongue on the edge of one engaging with the groove on the edge of the next. The coils thus thrust into the intense magnetic field constitute a disc, nine-sixteenths of an inch in thickness, and with an opening at the centre through which passes the revolving shaft. As there is no magnetic metal in the field, there are no eddy currents to waste the energy of the machine.

Not only are the several coils insulated carefully, but the stationary armature as a whole is insulated from the bed plate on which it rests. The coils are joined in series, the binding posts adjacent to any radial line of division between two coils constituting fixed terminals for the main line. There is no commutator; there are no collecting brushes to take the alternating current from rotating parts.

The low resistance of the armature coils is evident. It would seem impossible for one of them to burn out; none ever has burned out. But if one should, it may be removed and a new one readily put in its place in three minutes, or the injured coil may be shunted out of the circuit and the dynamo kept running with the other five until time for shutting down. The coil section complete, weighs only about 20 pounds.

The whole armature may be removed by loosening the coupling bolts, and sliding each half of the frame with its three coils from between the field magnets, figure 3. As each half with its coils, weighs only about a hundred pounds, no time need be wasted on cranes or blocks, and in a few minutes the armature may be back in position. There is no necessity to keep extra armatures on hand; a spare section or two will suffice for all probable emergencies.

In action, the 24 field magnets of the alternator are excited by the direct current from an 11-inch Brush dynamo of the well-known form. This exciting current is carried to the brushes that rest upon the two uncut insulated rings (shown at the left of figure 1), and thence through the hollow shaft to the magnets. A rheostat worked by hand or automatically, is placed in the shunt circuit around the field magnets of the exciter, so that regulation is secured without readjustment of the brushes or any necessity of handling the high tension alternating current.

The desire for a magnetic field of maximum intensity, has hitherto led to massive magnets encircling armatures with hundreds of pounds of iron core, upon which was wound a thin layer of conducting wire. But magnetization and demagnetization involve molecular movement of some kind and this movement develops heat. This heat is not only a waste of energy but diminishes the conductivity of all the coils, is destructive to insulation, and, in course of time, may destroy an armature in spite of lamination, perforation, ventilation and other devices.

With clear recognition of these scientific facts and their economic bearing, the electrical advisers of the Brush Electric Co. made no attempt to subdivide and ventilate a magnetic armature core, but promptly threw such contrivances overboard as useless for alternating dynamos. Of course, a revolving armature without an iron core would be structurally weak. This and other considerations led to the adoption of the fixed armature without any iron projecting into the magnetic field and, as the necessary complement of this, the rotating magnets.

The Brush "coreless" alternator is built at present for an E. M. F. of 2,000 volts, although it would be easy to develop a difference of potential much greater. It is confidently expected that the necessity of long-distance transmission with a line of moderate cost will soon call for currents of higher potential. Economy of power, as well as economy of copper, points in this direction.

The fall of potential in the machine from no load to full load is less than 10 per cent., as is shown in the curve

below (figure 4), which represents a diagram taken from one of the first machines. This result is obtained without compound winding or artificial regulation of any kind, a result, it is claimed, that has not been approached by any alternator with an iron core in its armature. All of the regulation needed is applied at the exciter as already described. This tends to the maintenance of an even distribution of potential in the feeders and at the converter terminals, and a consequent even pressure at the terminals of the lamps beyond.

In the Brush company's converter here represented (figure 5), the core consists of a polygonal ring made of insulated iron wire of the best quality, so wound as to leave several concentric air spaces in the core. In the converters of the smaller sizes, the core is built up of perforated thin iron plates (figure 6). In either case, the iron is so divided that the efficiency of the converter is little less with half than with full load. Upon each side of this core or iron ring, is wound a single layer of heavy copper wire. The four or five single layers of coils carried by each half of the core are joined in series and the two groups, borne by the two halves of the core, are joined in multiple, the whole constituting the secondary coil. The terminals of this secondary coil connect with the secondary main line running into houses and supplying current for the lamps. Most of the converters are wound so as to give a secondary current of about 100 volts but may instantly be connected to give 50 volts and twice as many amperes as before. They are made in sizes that supply each from 5 to 250 16 c. p. lamps or more.

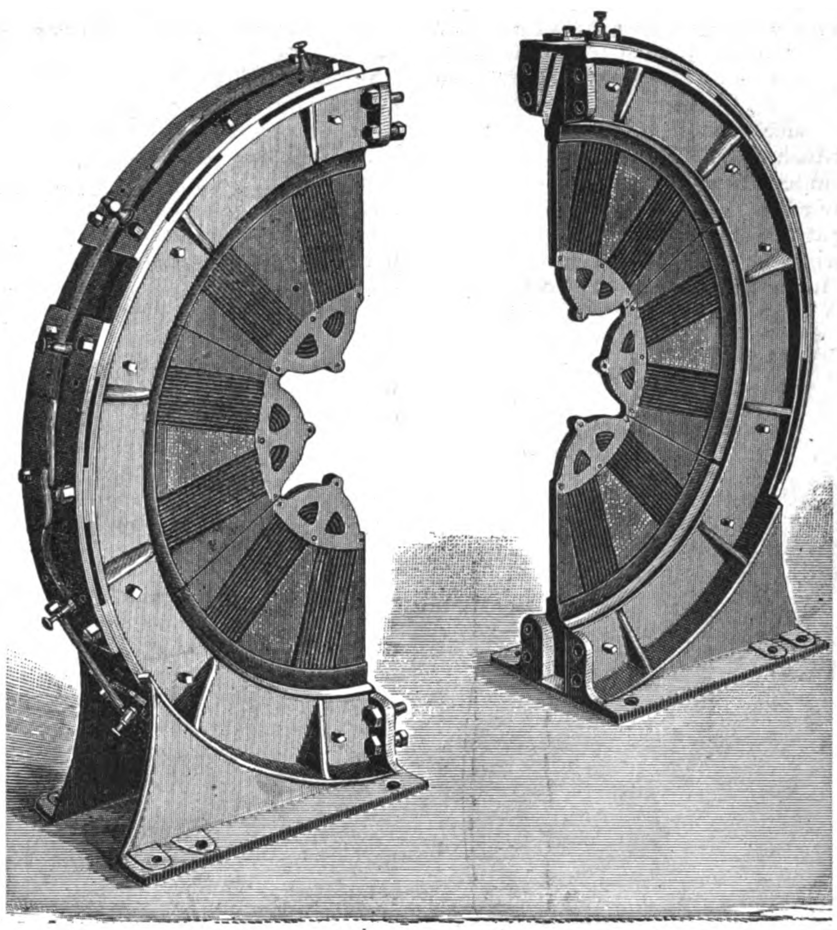


FIG. 3.—Armature of Brush Alternating Current Dynamo.

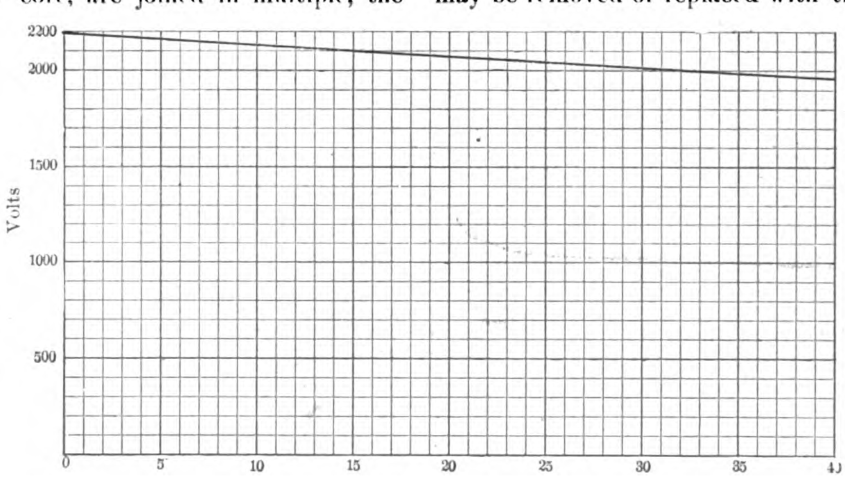


FIG. 4.—Potential Curve, Brush Alternating Dynamo.

Between the fine iron wire of the core and the heavy copper wire of the superposed secondary coil, insulating pads, one-eighth of an inch thick, are placed at the corners of the core. Between these insulating corner pieces are insulating air spaces. Thus the copper and the iron are separated from each other at the corners of the core by their respective coverings and the insulating pads; at all other points by their respective coverings and open air spaces, the latter affording ample ventilation and facility of examination. Over each of these single layer parts of the secondary coil, are wound a few layers of smaller copper wire to form a corresponding part of the primary coil. These corresponding parts of the secondary and primary coils are separated from each other by insulating pads at the corners and intervening air spaces, in the same manner and with the same advantages as previously described (figure 5).

The ventilation of these converters is found to be entirely satisfactory. The insulation resistance is exceedingly high. With the view of rendering it impossible so to overload the wire of the primary circuit as to force its high potential current into the secondary circuit and into premises supplied with light, the converters are tested at the factory with double load and no one has ever given out. Yet, to make safety doubly sure, overloading is made impossible by the use of safety fuses for the primary coils. These are extra long, so mounted on slate or porcelain strips that they may be removed or replaced with the fingers merely, and without touching any metallic part of the converter.

The converter coils, with safety fuses, etc., are placed in wind and weather proof cast-iron boxes (figures 8 and 8½), and may be placed wherever most convenient, the governing principle being to do as much work as possible with the less expensive primary wire, and to shorten the more costly secondary main. Thus the converter, as the local centre of distribution, is brought near the lamps it is to feed, and placed on the nearest line pole or on the wall of a building.

The Brush company's converters are now made of 11 sizes, supplying from two lamps to 250 lamps respectively.

With converters as with dynamos, the larger sizes are the more economical. With a 100 volt converter fed by

a 2,000 volt primary current, it is more easy and profitable to run a short secondary main to supply several consumers than to provide a converter for each consumer. Of course, the latter may be done if, for any reason, it seems desirable. But this desirability, it is thought, has been unduly magnified by those who have found converters of large size impracticable. On the other hand, the Brush Electric Co. claims that even its 98 per cent. of efficiency

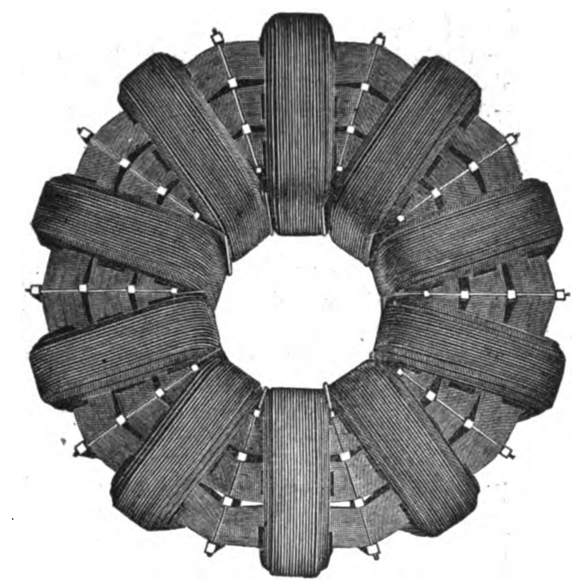


FIG. 5.—Brush Converter.

is exceeded in the larger sizes, and points out the additional important fact that as they are made of heavier wire in both primary and secondary coils, they are practically indestructible, and that there is no longer any need of placing a group of converters to feed a secondary main, or of furnishing a separate converter for each consumer.

An ammeter is placed in the main or feed circuit, wherever it is desirable to measure the strength of the current. It is a compensated expansion device (acting on

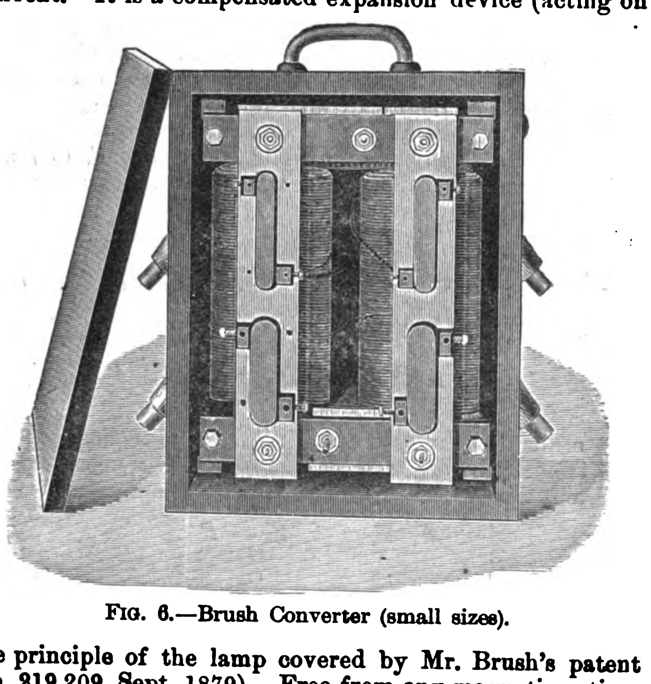


FIG. 6.—Brush Converter (small sizes).

the principle of the lamp covered by Mr. Brush's patent No. 219,209, Sept. 1879). Free from any magnetic action, the simple compensating arrangement insures the normal working of the apparatus at all temperatures. It is equally efficient with direct and with alternating currents.

The alternating current apparatus of the Brush Electric Co. here described, is based on the patents of Charles F. Brush and Gustav Pfannkuche, the latter having the supervision of this branch of the Brush Electric Co.'s business. From their experience thus far, the Brush company feel assured of the commercial success of their alternating system.

TWO STROKES OF LIGHTNING.[1]

BY J. W. MOORE.

The record of the following strokes of lightning is interesting on account of the following facts:—

1. That for 33 years the buildings and fences of the enclosure described were exempt, although entirely unprotected and in an exposed position.
2. That within a month the highest and lowest structures were both struck.
3. That the highest was not protected with a rod.
4. That the lowest was, unintentionally, partially protected.
5. That notwithstanding the excessive violence of the storm, comparatively little damage was done in either case.
6. That in the case of the fence, an ordinary barb wire acted as a conductor, and
7. That the damage to the fence was all due to lateral discharges from points.
8. That the relative value of conductors and non-conductors is clearly shown in the building struck.
9. That the advantage of an extended surface of metal over a smaller surface is evident.
10. That sudden bends act disadvantageously.
11. That breaks in the conductor are bad.

No attempt is made to theorize in reference to any of the above facts.

Whether these strokes took place when rain was falling, it has been impossible to determine with certainty, although the evidence points strongly to the presence of rain. It has been said that a child was overcome by the "return stroke," several blocks away, on the occasion of the stroke to the building, but investigation has failed to connect the two phenomena.

The enclosure mentioned, consists of 30 acres of land in the suburbs of Easton, Pa., and is used for fairs. The situation is elevated, although not as high as some of the distant surrounding country. The principal building is 152 feet long with a projecting front 25 x 26 feet. It was built about 35 years ago, has never had a lightning rod and until two years ago escaped all damage from lightning. This structure is the highest in the immediate vicinity.

On the roof is a large dome, the extreme top of which is at least 90 feet from the ground. The roof of the small dome which surmounts the large one is tinned; also the roof of the dome proper; the walk surrounding the whole and the roof of the building itself. On the north side extending the whole length of the eaves, is an open tin water conductor, connected with a closed tin pipe, vertical in position. The lower end of the latter is placed loosely in a horizontal wooden trough, which carries the rain water to the cistern. A piece of old tin pipe is in this trough. An ordinary chain pump is in the cistern. On July 31, 1887, during a short but terrific storm this building was struck. The finial on the top was split, a panel in the small dome torn out, and part of a window frame demolished. A stud three inches by six was splintered into fragments smaller and thinner than matches. The tin roof of the building proper and its connections prevented any further serious injury. The open water conductor was beaten out of shape, presenting such an appearance as would be produced by the rolling in it of a heavy ball from side to side. All the solder joints in this and in the vertical pipe were melted. A "ground" was made in the cistern. A peculiar corrugated appearance presents itself where the short weather boards abutting the wrecked

1. A paper presented to The American Association for the Advancement of Science, Cleveland meeting, 1888.

window frame were torn up. This seems to have been produced by the lightning in some way acting upon the iron nails.

The damage was greatest in the poor conductors. The wooden finial was torn to pieces, the tin roof was unhurt; the wooden panel was destroyed; the tin roof of the dome was unscathed; the wooden framework below was torn to shreds; the tin floor was uninjured. The wood-work below escaped, probably because the charge had nearly spent its force. Then the large tin roof formed a protection—the charge passing from this to the smaller surface of the water pipes produced the effect on them already described.

A month later, Aug. 30, 1887, the western part of the fence enclosing the grounds was struck. This fence is less than three-eighths of a mile from the main building above described. It is an ordinary board affair seven and one-half feet high, surmounted by a barb wire fastened to small blocks, to prevent the access of trespassers to the race course. One end of this wire was lying coiled up on the ground, a part of the wire having been removed to renew a portion of the fence. The length remaining attached was about 1,000 feet. On the west side of the fence at a distance varying from 250 to 300 feet is a large cluster of high trees; on the east, 14 feet distant, is a stable 200 feet long; 60 feet further east is the grand stand—a high structure with two unprotected flag staffs. Facing the grand stand is the judge's stand, with another unrodded flagstaff. The fence is the least prominent of all the objects in this part of the enclosure.

The barb wire is of the ordinary kind with four sharp points at every three inches. It is continuous excepting between posts 50 and 51 where there is a gate which leaned against the posts at the time of the flash. The posts are about nine feet apart; beginning at the north-west corner and numbering towards the south there are 82 posts. Numbers 6 and 82 limit the effects of the bolt. At 6, 36, 56 and 82 there are sharp corners, making sharp turns in the barbed wire.

The mechanical effects of the lightning are observable along the fence. Boards near numbers 6, 12, 14, 18, 20, 21, 22, 25, 27, 32, 33, 34, 40, 42, 47, 48 are splintered slightly or cracked. Near 51, the part of the gate next the break in the wire, is splintered. A board at 56 is split. Post, number 36—a locust—is split completely to the ground in two places. The wire touched the fence at this point. Number 42—a chestnut post—lost a piece five feet long, four inches wide and two inches thick. At 82 there is slight evidence of destructive action after which nothing unusual is observed, although the wire runs 300 feet further and ends near a telegraph pole and a wild cherry tree. The "points" show no evidence of heating. At the four sharp turns the damage is more pronounced than at the other posts, excepting number 42. The distribution of mechanical action it will be observed is peculiar. No attempt will be made to explain it.

Lafayette College.

MARCEL DEPREZ ON THE REGULATION OF THE SPEED OF ELECTRIC MOTORS.[1]

Designate by E, the electromotive force, V, the velocity, I, the average current, R, the total resistance of the two machines and the line, and give these letters indices of 0 and 1 accordingly as they indicate generator and motor.

First case.—The magnetic field and consequently the electromotive force of each machine (based on unit velocity) are functions of I, only when the inductor magnets are placed simply in series in the principal circuit. We have then—

$$E_0 = V_0 f_0 (I) \qquad E_1 = V_1 f_1 (I)$$

1. From *La Lumière Electrique*, vol. xxxii., No. 15. Abstracted and translated by Leonard Paget, Ph. D.

If the electro-magnets are double wound, that is to say, if one of the windings is traversed by the working current whilst the other winding is traversed by a current constant and independent of this working current, and independent of the velocity, we have still the same expressions for the electromotive force, the velocity not entering into the sign f_0 or f_1. It is under this latter hypothesis that we shall treat the problem, and we shall see that the solution is found in making this restriction apply even to the case where the second winding is traversed by a current taken from the terminals of the machine, as in "compound" winding. This understood, the current is given by the expression—

$$I = \frac{E_0 - E_1}{R} = \frac{V_0 f_0 (I) - V_1 f_1 (I)}{R} \qquad (1)$$

whence
$$V_1 = \frac{V_0 f_0 (I) - R I}{f_1 (I)} \qquad (2)$$

This equation gives the velocity of the receiver (motor) in function of the current quantity, and this quantity is connected to the couple developed by the ring of the motor by the relation

$$F_1 = \frac{I f_1 (I)}{g} \qquad (3)$$

in which F_1 expresses in kilogrammes the effort developed by the ring at the end of a lever arm equal to unity, the velocity V_1 of the ring being then equal to the number of meters traversed by the extremity of this lever-arm in the unit of time. This relation permits of easily constructing by means of the "characteristic" the curve of quantities in function of the mechanical efforts, and consequently by means of the equation (2) of finding the velocity of the motor in function of F_1.

Let it be proposed, however, to seek under what conditions the velocity V_1 may be maintained constant, that is to say, independent of the amount of motor work that the receiver may have to develop during a revolution. It is to be understood that the generator has constant speed.

The complete discussion of equation (2) needs that we know exactly the analytic form of the functions $f_0 (I)$ and $f_1 (I)$, that is the characteristic of the two machines. We can replace this advantageously by a geometrical investigation based on graphical construction when we have the curves themselves. When the current is comprised within limits for which we have the right to consider $f_0 (I)$ and $f_1 (I)$ as linear functions of I, the characteristic becomes sensibly a straight line.

Putting

$$E_0 = V_0 (a_0 + b_0 I) \qquad E_1 = V_1 (a_1 + b_1 I)$$

equation (2) then becomes

$$V_1 = \frac{a_0 V_0 + (b_0 V_0 - R) I}{a_1 + b_1 I}$$

In order that the value of V_1 may be independent of I that is of F_1, which is the end proposed, it is necessary and sufficient that we have

$$\frac{a_0 V_0}{a_1} = \frac{b_0 V_0 - R}{b_1}$$

whence
$$V_0 = \frac{a_1 R}{a_1 b_0 - a_0 b_1}$$

and
$$V_1 = \frac{a_0}{a_1} V_0$$

This expression is very remarkable. *It shows that whatever may be the values and the signs of the co-efficients, a_0, b_0, a_1, b_1, or the value of R, we may always resolve the problem proposed by giving to the generator a velocity*

that depends only upon these co-efficients. It is the same for V_1, of which the value is then—

$$V_1 = \frac{a_0}{a_1} V_0$$

Let us suppose that the inductor electro-magnets of the two machines are mounted with simple winding placed in series in the principal circuit and traversed by the working current. We then have

$$a_0 = o \qquad a_1 = o\,;$$

whence results for V_0 an indeterminate value. Then in this case, the problem is always solved whatever may be the velocity of the generator.

The velocities V_0 and V_1 are then connected by the equation

$$V_1 = \frac{b_0\ V_0 - R}{b_1}.$$

If the machines are identical this relation may be put under the form

$$V_0 - V_1 = \frac{R}{b_0}$$

Second case.—The motor (receiver) has a constant magnetic field. We have then $b_1 = o$.

$$V_0 = \frac{R}{b_0} \qquad V_1 = \frac{a_0\ R}{a_1\ b_0}$$

These equations can be satisfied only under the condition that neither a_0 and b_0 are nil. The generator should have, in this case, a double winding.

Third case.—The field of the generator is constant. We have consequently

$$b_0 = o$$

whence $\qquad V_0 = \dfrac{a_1\ R}{a_0\ b_1} \qquad V_1 = -\dfrac{R}{b_1}$

a_0 and a_1 being positive, b_1 should be negative, that is to say, the magnetic field of the receiving motor should diminish as I increases. This is the case that M. Deprez treated several years ago, when he sought what conditions must be satisfied so that a receiving motor should have its velocity independent of the resisting couple when the difference of potential at its terminals is kept constant (see *Comptes Rendus*, vol. ci., pp. 1128–1162).

En resumé, we see that with two machines, the electro-magnets of which are furnished with any winding, the problem proposed may always be resolved, apart from the single case where the magnetic fields of the two machines are constant. In this case, the velocity v of the motor and the resistant couple f are connected by the equation

$$\frac{f}{F} + \frac{v}{V} = 1$$

in which F and V are easily defined constants of the motor.

Whilst the function $f\ (I)$ is given graphically by the characteristic, it is very easy to construct the characteristic that the motor should have to obtain a velocity independent of I. From equation (1) we deduce

$$f_1\ (I) = \frac{V_0 f_0\ (I) - R\ I}{V_1}$$

But $V_0 f_0\ (I)$ is the ordinate $M_0\ P$ (figure 1) of the characteristic $C_0\ B\ M_0\ M_0^1$ of the generator at the velocity V_0, and $R\ I$ is the ordinate $N\ P$ of the line $O\ N\ M^1$ represented by the equation $y = R\ I$. The difference $M_0\ P - N\ P$ is then equal to the ordinate $M_1\ P$ for the motor at the velocity V_1, and it is sufficient to divide this ordinate by V_1 to obtain the ordinate corresponding to unit velocity.

It is thus that the curve $B\ M_1\ A$ has been constructed, which shows the form of the characteristic of the motor revolving at a constant velocity V_1. We see that in the particular case represented by figure 1, the magnetic field of the motor decreases when I increases; whilst the contrary takes place with the generator; but this condition is not at all necessary, as we have already seen, and as we can again state graphically.

If the characteristic of the generator instead of having the curve indicated in figure 1, was represented by the line $B\ M_0^1$, the characteristic of the receiver would then necessarily be also a right line, $B\ A$.

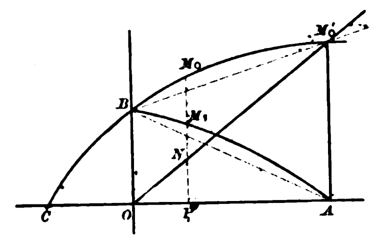


Fig. 1

Figure 2 shows that we can obtain a velocity independent of I, whilst the receiving motor has a constant magnetic field. It is requisite then that the characteristic of the generator should be rectilinear, parallel to the line $y = R\ I$ (this condition may always be fulfilled by giving a

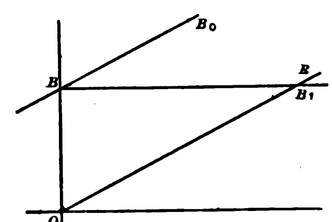


Fig. 2

suitable speed), and finally that the ordinate $O\ B$ corresponding to $I = o$ should be equal to the constant ordinate of the characteristic of the motor revolving at velocity V_1.

Figure 3 is an example of the case where the magnetic field of the motor is increasing with I as also that of the generator, the two machines being double wound.

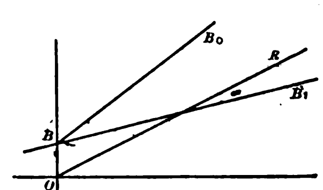


Fig. 3

Now we can, in practice, nearly approach this hypothesis, under the condition that the magnetic flux in the cores of the rings and of the magnets does not exceed the value of 6,000 C. G. S. units.

In the case where we wish to obtain a constant velocity of the motor in working with magnetic fields approaching saturation, it is necessary to modify the value of R by intercalating, in the circuit of the ring of the motor, a rheostat put into action by a centrifugal force regulator. The efficiency having for its value $\dfrac{E_1}{E_0}$ will then be constant and independent of intercalated resistances.

....AN inscription has been placed over the American section in the machinery hall in the Paris exposition which, though brief, is full of interest. It states that the United States possesses steam engines of 450,000 horse-power, the power of which is transformed into electrical energy; and that, apart from transmission of power, this energy is used to supply current nightly to 2,000,000 incandescent lamps and 250,000 arc lamps.—*Exchange.*

ARC LAMPS AND THEIR MECHANISM.[1]

BY PROFESSOR SILVANUS THOMPSON, D. Sc., M. I. E. E.

(Continued from page 304.)

WE are now prepared to enter upon the mechanical devices which have been suggested for the feeding-mechanism of lamps. These are so varied, and run so curiously into one another, that no classification of them is entirely satisfactory. In a very large class of lamps there is a train of wheel work, usually driven by the weight of the descending carbon rods, the last member of the train being controlled through a detent or brake, by the electro-magnet that is responsible for the feeding of the lamp. Most, but not all, of these lamps have a rack upon the upper carbon rod to drive the train. But the rack lamps differ greatly amongst themselves. Again, there is another class of lamps in which the upper carbon rod is smooth, but is assisted and controlled in its descent by a clutch or clamp, the clutch or clamp being in turn controlled by the feeding electro-magnet. But there are also rack lamps in which a clutch or clamp is applied, not to the rod itself, but to a wheel driven by the descending rack. There are, however, certain main features of classification about which there need be no ambiguity.

FEED MOTIONS.

[*i.*] *Rack and Train* controlled by—
- (*a*) Star wheel and detent [Staite, 18,783^{47}; Foucault-Duboscq; Serrin, 653^{59}.]
- (*b*) Fly and detent [Staite, 1848; Duboscq, 1855].
- (*c*) Brake-wheel and brake [Chapman, 789^{55}; Crompton, 346^{82}].
- (*d*) Escapement with pendulum or balance and detent [Siemens, 4,949^{78}; Harding, 3,166^{81}; Waterhouse, 5,185^{81}].
- (*e*) Escapement and paddle [Waterhouse, 5,185^{81}].
- (*f*) Governor with detent or moderator [Waterhouse, 5,185^{81}].
- (*g*) Magnetic brake-wheel or detent [Brockie, 1,718^{82}; Harling, 3,473^{81}].
- (*h*) Liquid brake [Hopkinson, 153^{81}].

[*ii.*] *Clutch or Clamp on Rod.*—
- (*a*) Tilting ring, tilting eyelet, &c. [Slater and Watson, 212^{52}; Brush, 2,003^{78}; Lumley, 1,249^{82}; Lever, 2,092^{82}; Thomson-Houston; Waterhouse, &c.].
- (*b*) Split cone gripped by fork [Slater and Watson, 212^{52}].
- (*c*) Split nozzle forced into cone mouthpiece [Bürgin, 4,820^{81}].
- (*d*) Split tube held together by oblique levers [Rogers, 3,236^{82}].
- (*e*) Gripping springs at side [Lever, 3,599^{81}; Munro, 1,626^{83}].
- (*f*) Gripping fingers [Roberts, 14,198^{82}; Joel, 5,157^{79}; "devil's claws," Harding, 3,166^{81}].
- (*g*) Washer jambed by ball bearing [Young, 1,689^{82}; or roller, Newton, 4,559^{81}].
- (*h*) Tilting clamp or nipping clamp [Common, 626^{82}].
- (*j*) Nipping lever [Grimstone, 1,670^{81}; Mondos, 5,490^{81}].
- (*k*) Scissors lever [Joel, 3,970^{84}; Jarman, 563^{82}; Gerard-Lescuyer, 2,992^{82}].
- (*l*) Spiral spring surrounding rod [Keilhotz, 1886; Thouvenot, 1887].
- (*m*) Forward-pointing springs (lobster-trap) [Newton, 1,623^{83}; Clark-Bowman, 1,182^{83}; Holmes, 769^{86}; Hawkes, 157^{82}].

[*iii.*] *Clutch-wheel or Brake-wheel*—
- (*a*) Nipping lever outside brake-wheel [Gramme, 1861; Common and Joel, 1,040^{81}; Brockie, 4,419^{83}].
- (*b*) Nipping lever inside rim of wheel [Union Co., 392^{82}; Brockie, 4,419^{83}].
- (*c*) Elastic band brake [Statter, 2,985^{85}].
- (*d*) Elastic internal ring brake [Siemens, 6,987^{87}; Fein, 1888].
- (*e*) Wheel lifted against brake or detent [Bürgin, 4,820^{81}].
- (*f*) Brake-wheel lifted upon brake-lever [Gümpel, 253^{81}; Crompton-Crabb, 2,539^{83}].
- (*g*) Friction-pad on rim of wheel [Abdank, 1882].

[*iv.*] *Screw Motion*—
- (*a*) Screw worked by weight of upper rod [Hopkinson and Muirhead, 153^{81}; Cance, 3,976^{81}; Akester, 2,419^{82}].
- (*b*) Screw worked by motor [Tchikoleff, 1874].
- (*c*) Screw worked by step-feed [Street-Maquaire, 9,666^{88}].
- (*d*) Screw worked by vibrated wheel [Siemens, 6,987^{87}].

[*v.*] *Cord and Pulley Motions*—
- (*a*) Cord and pulley to core of solenoid [Archereau, 1848; Jaspar, 83^{79}].
- (*b*) Cord and Pulley connecting carbons, with long-travel solenoid [Pilsen lamp, 1,397^{80}; Doubrava, 1,033^{86}].
- (*c*) Cord gripped by controlling cam [Harding, 4,590^{79}].
- (*d*) Cord and pulley for differential feed [Weston, 1883; Kennedy, 1888].

[*vi.*] *Step-by-Step Motions*—
- (*a*) Step detent worked by electro-magnet [Deleuil, 1856; Brockie, 898^{82}; Gatehouse and Kempe, 2,569^{83}; Kennedy, 5,524^{81}].

[*vii.*] *Magnetic Clamps and Clutches*—
- (*a*) Tilting magnet clutch on rod [Roberts, 14,198^{82}; Gülcher, 2,038^{81}].
- (*b*) Magnetic clamp on brake-wheel [Harling and Hartmann, 3,473^{81}; Hardt, 1886].

[*viii.*] *Electric Motor Action*—
- (*a*) Motor screws carbon up or down [Tchikoleff, 1874, and 2,198^{81}; Maquaire, 1889].
- (*b*) Winds up with cord or rack [Andrews, 2,321^{79}; André, 2,764^{80}; Bousfield, 523^{79}; Breguet, 1879].
- (*c*) Motor itself controlled by shunt magnet [Thomson-Houston, 315^{80}].
- (*d*) Motor with copper damper [Thury, 1888].

[*ix.*] *Hydrostatic and Pneumatic Action*—
- (*a*) Carbons controlled by admission of liquid or gas [Lacassagne and Thiers, 2,456^{56}; Hopkinson, 3509^{80}; Leibold, 1886; Sedlaczck, 1883].

[*x.*] *Vibrating Feeds*—
- (*a*) Make-and-break lever vibrate forward-pointing springs [Newton, 1,623^{83}; Piper, 4,647^{85}; Holmes, 769^{86}].
- (*b*) Make-and-break lever actuates escapement [Harding, 3,166^{81}].
- (*c*) Make-and-break lever actuates detent on train [Gramme, 1880].
- (*d*) Make-and-break lever hammers rod through clutch [Letang, 5,509^{87}].
- (*e*) Make-and-break lever works internal clutch-wheel feed [Fein, 1888].
- (*f*) Make-and-break lever drives pallet and screw feed [Siemens (Alteneck), 1885].

[*xi.*] *Periodic Feeds*—
- (*a*) Periodic drop of upper carbon and lift through definite range [Brockie, 898^{82} and 1,718^{82}].
- (*b*) Periodic currents to magnet sent through second wire [André, 4,948^{81}].

[*xii.*] *Continuous Feeds*—
- (*a*) Clockwork step feed, length of stroke varied by magnet [Brockie, 898^{82}].
- (*b*) Pendulum or governor, having rate varied by magnet [Waterhouse, 5,185^{81}].
- (*c*) Rack-train controlled by magnetic retardation on copper wheel [Niaudet, 1878].

[*xiii.*] *Hammering Feeds*—
- (*a*) Rod driven through clutch by vibrating hammer [Letang, 5,509^{87}; Capito and Hardt, 1887].
- (*b*) Ditto, by tilting lever [Jolin, 2,570^{83}].
- (*c*) Ditto, by magnetic pile-driver on rod [King, 1888].

Outside the classification adopted above are several well-marked features of mechanism; one of these is the *parallelogram motion.* A typical case of this is afforded by the well-known Serrin [653^{59}] lamp (figure 5). A jointed parallelogram is constituted by the pieces which meet at A B C D. The side, A C, is fixed, being part of the frame, whilst the levers, A B C D, rise and fall through a small angle, carrying with them the upright, B D. To this upright is fastened a sleeve, through which the lower carbon-holder passes. This moving parallelogram is held up by a spring, *s.* When the electro-magnet, E (in main circuit), attracts its armature, *a*, the parallelogram, and with it the lower carbon, sinks, and so the arc is struck. At the same instant a projecting triangular detent, U, engages against the star wheel of the driven train and locks it, so that the upper carbon cannot descend. As the carbons are consumed the current is weakened, owing to the increasing resistance of the lengthening arc, and the electro-magnet lessens its attraction; consequently the parallelogram gradually rises, until a moment occurs when the detent ceases to lock the star wheel. The upper carbon-holder is now free to descend a little, driving the train of wheels, shortening the arc, restoring the normal current, and so again causing the electro-magnet to pull down the parallel-

1. Paper read before The Society of Arts, London, March 6, 1889.

ogram and lock the wheels. Parallelogram motions are to be found also in Bürgin's lamp [4,820[81]], and in Siemens' pendulum lamp [4,949[78]].

Another characteristic mechanism is the *see-saw* lever. Figure 6 shows the form used in the Brockie-Pell lamp [1,268[85]]. The earliest use of the see-saw, attracted at opposite ends by series and shunt magnets respectively, occurs in the lamp of Lacassagne and Thiers [2,456[56]];

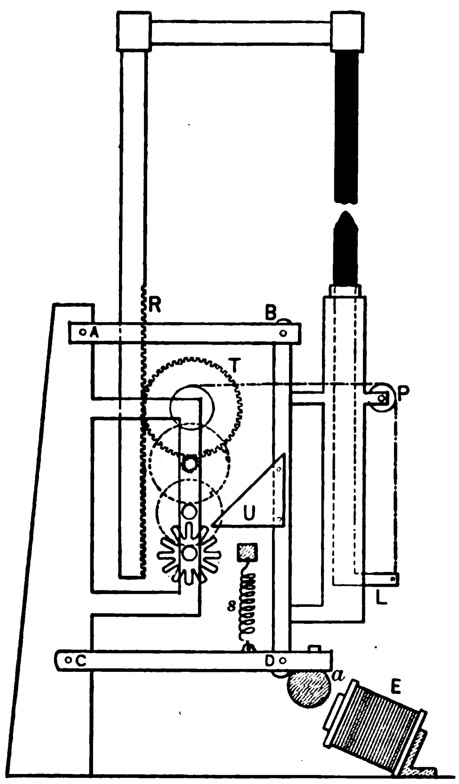


FIG. 5. SERRIN'S LAMP.

whilst modern examples are Weston's lamp, the Thomson-Houston lamp (figure 14), and Fein's lamp of 1883. [Also Moffat and Chichester, 3,441[81]; the Chadburn, 2,755 where the see-saw works a clutch]. A compact modification of the see-saw mechanism occurs in one form of Weston's lamp, and again in Kennedy's lamp of 1888, figure 10. Here the lever is replaced by a pulley over which passes a cord or ribbon of metal. In this lamp the shunt

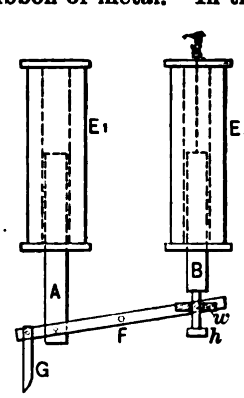


FIG. 6. SEE-SAW OF BROCKIE-PELL LAMP.

solenoid is furnished with a plunger core, whilst the series solenoid on the left has a plunger and an external iron mantle to increase its power. The smaller pulley communicates the motion to a clutch. The advantage of the see-saw, and of its pulley equivalent, is that such an arrangement enables the lamp to be used as either a constant potential lamp or as a constant current lamp. In the former case the shunt coil holds up its end, whilst the see-saw is operated by the variations of the current in the series coil. In the latter case the actions are the inverse of this.

The *rack-train* mechanism which forms the first-class in the preceding list, presents two special points. As this mechanism is in itself non-retractile, and can only propel the carbons forward, it cannot be used with non-homogenous carbons of second quality, unless special provision is made in the striking mechanism of the lamp for a retractile movement. There is nothing retractile, for example, about the Breguet lamp (figure 3), but there is about the Serrin (figure 5), for the lower carbon-holder (which descends to strike the arc) is never held tight down by the electro-magnet, but takes up a position of equilibrium. The other point is that in these rack-train lamps some device is requisite to lock the train at the instant of striking, otherwise the feed motion would neutralize the strike-motion. In some lamps [Breguet, Sellon, etc.] there is a mechanical connection from the striking part to lock the feed. In some other lamps the action is performed electrically. In the De Puyt lamp (figure 23), a pin on the train frame engages with a forked connecting-piece from the feeding-lever.

A characteristic arrangement, applicable to rack-train lamps, is that in which, for the purpose of striking the arc, the whole train mounted in its framework, together with the rack and the upper carbon-rod, is bodily lifted by the use of an electro-magnet in the main circuit. [Crompton, 346[82]; Fyfe and Main, Hochhausen, Gümpel, Berjot, Wood, Maxim, &c.] More neat is the method of rocking the train bodily around the axis of one of the wheels of the train. [Brockie, 2,370[82]; and De Puydt, figure 23.]

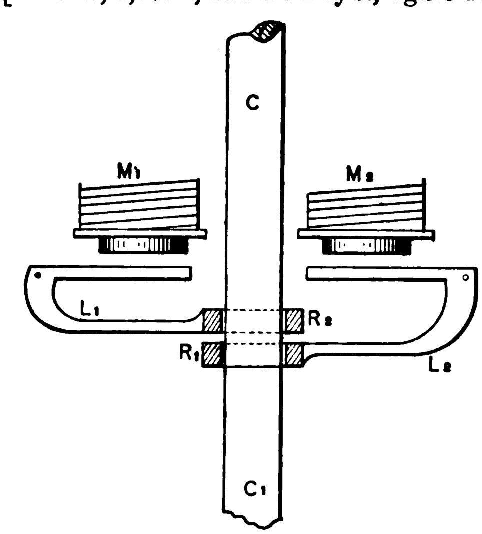


FIG. 7. SLATER AND WATSON'S CLUTCH.

Passing from the *rack-train* lamps to the *clutch* lamps, it may be noted how much ingenuity has been expended in attempting to find a form of clutch which will prove reliable under all conditions of working. Two of the very earliest forms of clutch mechanism are worth recalling in this connection. These are both due to Slater and Watson [212[52]]. The first (figure 7) shows a carbon rod sliding through a couple of rings or eyelets, which are tilted by the attraction of an electro-magnet to grip and raise the rod. In the second (figure 8) the clutch consists of a split conical washer, the two halves of which are hinged together. These are compressed by the rising of a fork, which nips and raises them. The tilting ring introduced by Brush is too well known to need comment. Lever's modification of the tilting ring is shown in figure 9, the rim below the ring causing the thrust to act more obliquely at first, and allowing the clutch to work even when the aperture is considerably worn. In the latest forms of this clutch, the ring has a tail-piece which is hinged to the frame of the lamp. Another successful form of tilting

clutch is shown in figure 10, which represents the mechanism of Kennedy's lamp. The clutch has a long tail, provided with an adjusting screw to regulate its position, and bears against the carbon rod by a slender spring, *s*, above. It is worked by a thin cord, *d*, running over a pulley in connection with the differential arrangement of shunt, s, and series, M, solenoids described above. A clutch provided with a spring that bears against the carbon rod is also found in the Clark-Bowman lamp [1182[83]], the feeding in this case being accomplished whilst the clutch is held up, by giving to it a mechanical vibration. In the Kennedy lamp the spring on the clutch also serves the purpose of finally

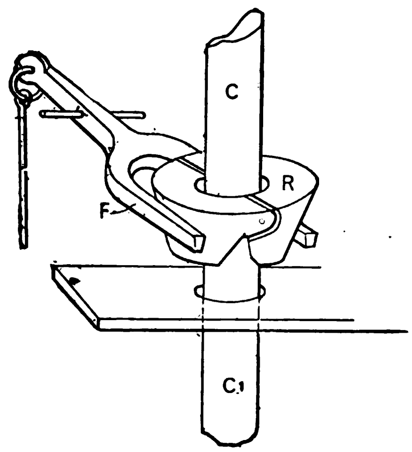


FIG. 8. SLATER AND WATSON'S SPLIT CONE.

arresting the descent of the carbon holder, catching on a groove cut around its upper end when the carbon pencil is all consumed. Another simple clutch with spring mounting, worked by the mutual repulsion between two similarly magnetized cores, has been devised by Swinburne [11,893[86]]. Clutches of the knee-lever type have been devised by Lorrain [183[8]] and Joel [3,970[84]]. The more complex "scissors-joint" levers, used in one of Joel's lamps, are drawn in figure 11. Their action is obvious, as their upper end is raised by the upward pull of the electro-magnet or solenoid they grip, and raise the carbon rod, and they relax their grip on being lowered to feed the arc. Very similar

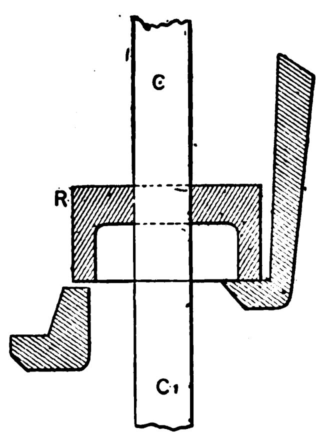


FIG. 9. LEVER'S CLUTCH

devices are found in Gerard's and Jarman's lamps. An ingenious species of clutch, by F. M. Newton [4,559[81]], is illustrated in figure 12. This consists of a ball-bearing or roller-bearing, which on the raising of the collar in which it lies jams against the carbon rod and raises it. Another extremely simple clutch [Lorrain, 639[83]], consists of a plunger working horizontally through a solenoid, pressed sideways by a spiral spring against the carbon rod; the pressure of this is taken off, when feeding is required, by the pull due to the current in the solenoid, which is connected as a shunt. Rogers's [3,236[82]] simple and very efficient form of clutch consists of a split-tube, the parts of which are connected together by a pair of oblique links,

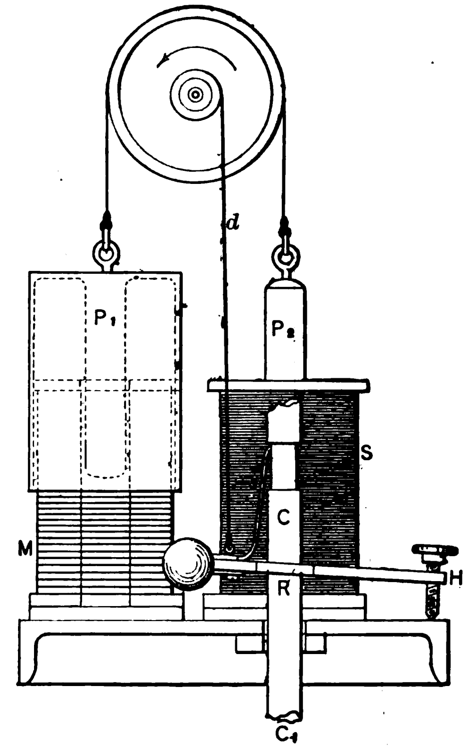


FIG. 10. KENNEDY'S LAMP.

making a sort of parallel motion. This form is shown in figure 13.

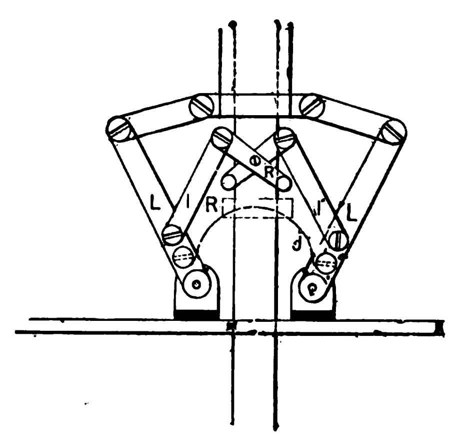


FIG. 11. JOEL'S SCISSORS JOINT.

In the Thomson-Houston lamps, so widely used in the United States, a peculiar clutch is employed, consisting of

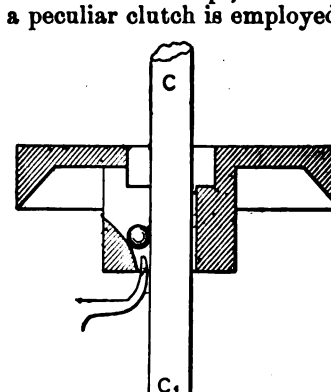


FIG. 12. NEWTON'S ROLLER CLUTCH.

a pair of levers jointed together, one of them being perforated with an eyelet through which the carbon rod passes.

The mechanism of this lamp, shown in figure 14, consists of a see-saw lever, L L, pivoted at O, and provided with a long tail, T, the motion of which is moderated by an air

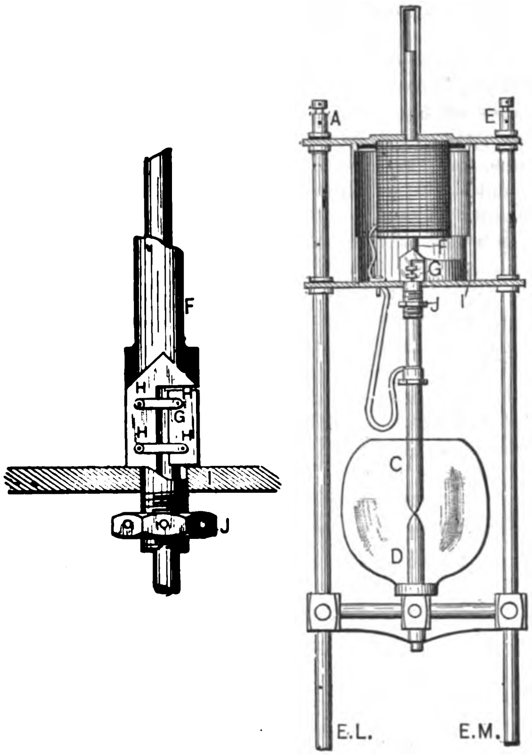


FIG. 13. ROGERS' CLUTCH.

dash-pot. Below is an electro-magnet, M, in the main circuit, and above is a second, S, which is connected as a shunt. The pole-pieces of both are of conoidal shape, pro-

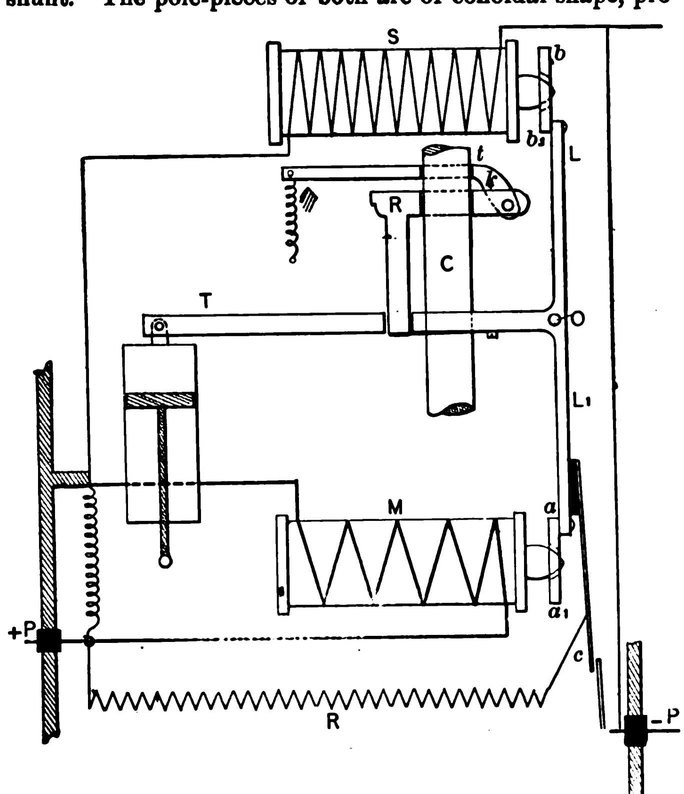


FIG. 14. MECHANISM OF THOMSON-HOUSTON LAMP.

truding through apertures in the armatures, *a a*, and *b b*, to give longer range of pull. The lower and upper arms of the clutch, marked R and K, close together when the tail, T, rises, gripping the carbon rod, C, and raising it. From this diagram, which also shows the electric connections, it appears that the current entering the lamp through an insulated terminal at + P, flows first round M, and then goes to the frame of the lamp. Thence it divides, the main current finding its way to the upper carbon holder, and so through the arc to the lower carbon, whence it returns (by a route not shown) to the insulated negative terminal,— P. A smaller portion of the current flows up round the shunt electro-magnet to— P. The arc is struck by the preponderating main-circuit current in M attracting the lever end of the see-saw lever, and raising the clutch. The feeding is accomplished by the preponderating pull of the shunt magnet as the arc increases in length. The resistance wire across from + P to *c* constitutes a cut-out circuit, which is brought into operation by the augmented current in S on any failure of the main current. The small coil connected across from + P to the lamp frame is a mere adjustment to regulate once for all the power of the series coil, *m*, relatively to that of the shunt coil S.

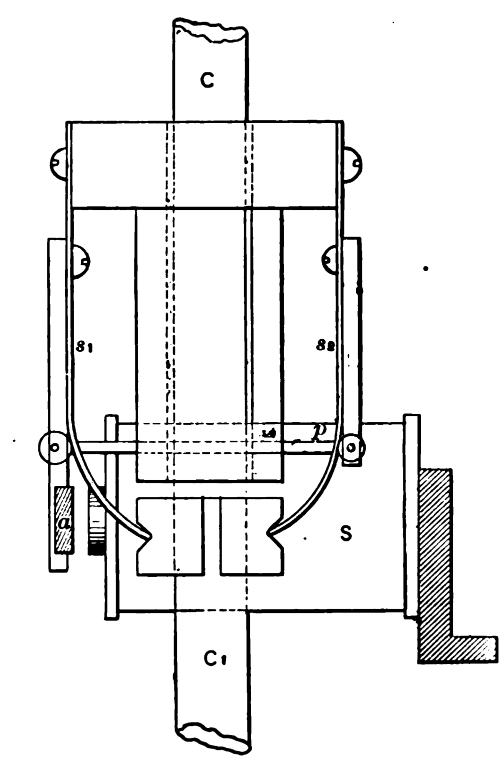


FIG. 15. HOLMES'S FEED.

It will be noted that in the operation of all these clutch actions there are really four periods. In striking the arc there is a first stage of affairs, where the clutch rises sufficiently to grip the carbon rod immediately followed by a second stage, during which it rises still further, and lifts the carbon rod, so striking the arc. During the third stage or period the clutch still retains its grip, but as the arc burns away the clutch is gradually lowered. This is due, in constant potential lamps, to the weakening of the main current; in constant current lamps, to the increasing opposing action of the shunt. The fourth stage is reached when the arc has burned away so far that the clutch has been lowered to the point where it begins to relax its grip, and now feeding commences, the rod slipping a little, but the clutch simultaneously rises a little, and grips again, again to descend. In a well-adjusted clutch lamp the clutch is indeed incessantly rising and falling through minute distances about the critical position. A bad clutch, or one that is deranged by dirt, will overfeed, and then rise too far, feeding spasmodically. Theoretically, all these clutches possess the retractile property so useful in keeping a steady arc when the carbons are of indifferent

quality. But it is obvious that their perfection of action is impaired by dirt, dust, and inequalities in the surface of the carbon rod due to wear and tear.

Clutches of the class termed "forward-feeding" belong to a different category, as they have, for the most part, no retractile power. In Newton's form [1,623[83]] a piece of steel curry-comb, bent so as to form a sort of lobster-trap, encircles the carbon rod, and forces it gradually forward when mechanical vibrations are imparted to it by a lever, working with a vibration on the plan of the well-known electric-bell vibrator, from the armature of a shunt-magnet. The latest variety of this species of forward feed is that of Holmes [769[84]], shown in figure 15. Here, a shunt electro-magnet, S, attracts an armature, *a*; the latter being mounted upon a vertical lever. The carbon-rod, $C\ C_1$, is gripped between two blocks which are pressed against its sides by two curved springs, s_1 and s_2. The armature lever is attached to s_1, and is connected across by a small rod, *p*, to the spring s_2. When the armature, *a*, is alternately vibrated backward and forward by the magnet, the gripping blocks propel the carbon downwards. The make-and-break device which turns the current off and on in the magnet coils, is not shown in the cut. It consists of an ingenious modification of Holmes's snap-switch.

Passing to the *clutch-wheel* or *brake-wheel* type of lamps, we may remark that although so far back as 1861, Gramme attempted to construct on this plan a lamp (the existence of which was only published to the world in 1888, by

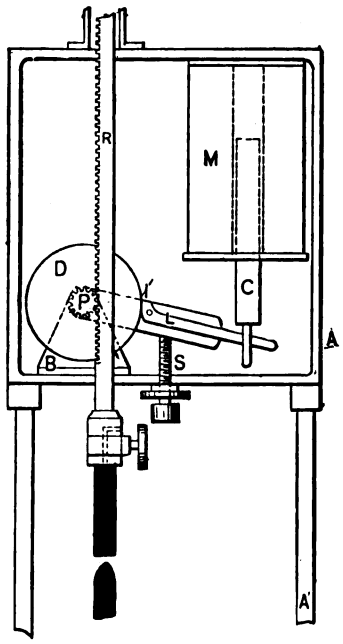


FIG. 16. COMMON AND JOEL'S CLUTCH-WHEEL.

M. Fontaine), this species of mechanism appears to be essentially British. The device of applying a clutch to a wheel in order to feed that wheel forward by degrees, the reciprocating motion of the clutch lever being converted into a motion of rotation of the wheel, is already familiar to engineers in the so-called "silent feed" movements used in spinning and weaving machinery. A clutch applied to the periphery of a wheel first grips the wheel, then turns it a little. In weaving machinery the "feed" acts in the direction in which the clutch propels the wheel, but in its application to the arc lamp the action is reversed, for the weight of the carbon rod propels the wheel in a direction opposed to the grip of the clutch, and the feeding takes place at those instants when the clutch releases its grip. The matter is best studied by reference to actual cases. Figure 16 depicts the clutch-wheel of Common and Joel. The descending rack, R, drives the wheel, D, by means of the pivot, P. Pivoted loosely around the same arbor is a heavy lever, which is prevented by a stop, S, from descending too far. Pivoted to this lever at L is a second lever, with an enlarged end to grip against the surface of the wheel. The tail of this nipping lever is attached by a pin to the iron core of a solenoid, M. (The latter is wound with a main-circuit coil only if wanted for use in parallel, or with a main coil and an opposing shunt coil if for use in series.) When the current in the solenoid draws up the core, the nipping lever first turns around L and grips the wheel; any further rise of the core will cause the two levers and the wheel to turn bodily together round the arbor, and this second action causes the arc to be struck. Then begins the third period of action, during which the levers slowly descend until the weight-lever touches S. Then the fourth period begins; any further descent of the core causing the nipping lever to release its grip, and allowing feeding to take place, followed by a slight rise in the core and renewal of grip.

A form of clutch-wheel lamp which has become deservedly popular of late is that known as the Brockie-Pell [4,419[82] and 12,681[85]]. The see-saw belonging to this lamp was shown in figure 6. The descending carbon rod drives a wheel having a strong projecting rim, at the inner surface of which a brake is applied. This consists of a small leather pad, *m*, fastened to a short arm

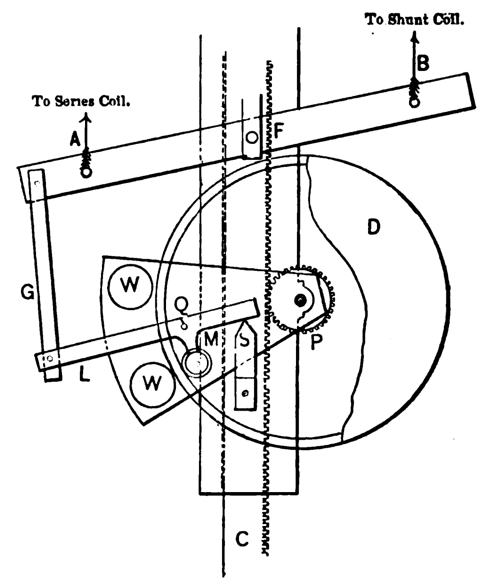


FIG. 17. BROCKIE-PELL LAMP.

which projects downwards from the nipping lever, L, pivoted at Q to a sector-shaped lever behind, which carries two weights, W W, to increase its downward-bearing power. This weight-lever is loosely pivoted on the arbor, P, and turns solidly with the wheel when the brake is applied. There is a stop, S, to limit the descent, but it is in this case applied to the tail of the nipping lever. A connecting link, E, joins the nipping lever, L, to the see-saw. The internal position of the brake appears to have two advantages, namely, longer leverage around the fixed pin, making the feed more sensitive, and greater protection from dust and dirt. One peculiarity of the Brockie-Pell lamp is seen by reference to figure 6, namely, the device by which the core, B, of the shunt coil is allowed a certain travel upwards before it pulls at the see-saw lever, its thinner part passing freely through a swiveled washer, *w*, on the see-saw. But the washer is of iron, and the core has an enlarged head, *h*. These adhere by magnetic attraction when the shunt coil comes into operation.

Another very successful form of lamp is the Crompton-Crabb "double differential" [2,539[82]], shown as a whole in figure 18, and in detail in figure 19. In the lamp shown in figure 18 there are two carbon rods, M and N, of which N comes first into operation, afterwards changing

over. On each carbon rod is cut a rack which drives a brake-wheel, or, rather, a pair of brake-wheels, one behind the other on the same pinion. The arbor bearing is not, as in the two preceding lamps, fixed in the frame of the lamp, but passes through a short sleeve or jockey, which, when the wheel is free to turn, can slide up or down on the carbon rod, but is prevented from turning sideways by a guide pin, *g*, above. Below the brake-wheels stands a lever, L, pivoted at *o*, and attached by a link, H, to the core of the solenoid overhead. This lever carries a small table, *t*, and a brake-piece, *b*, faced with phosphor-bronze.

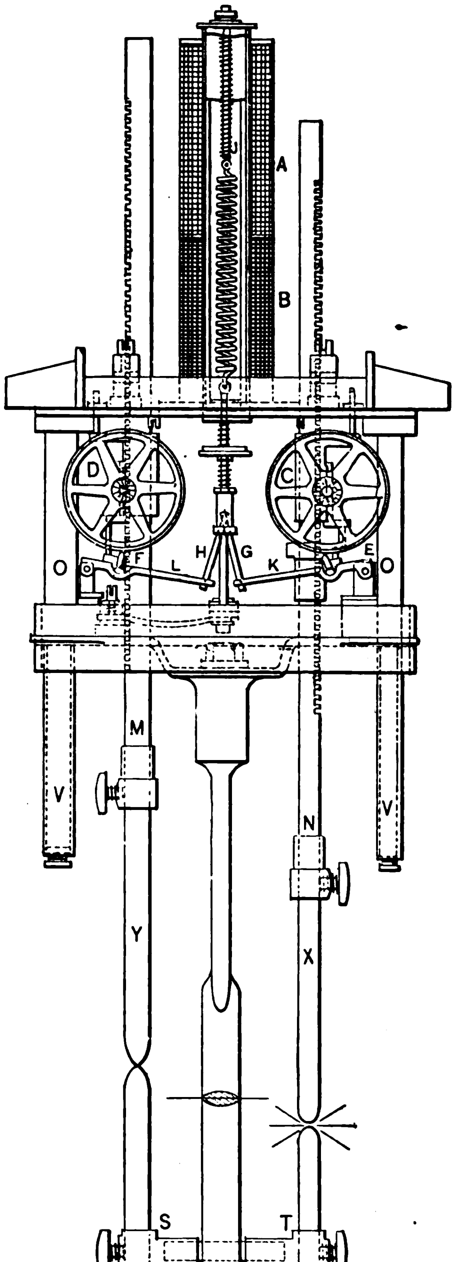
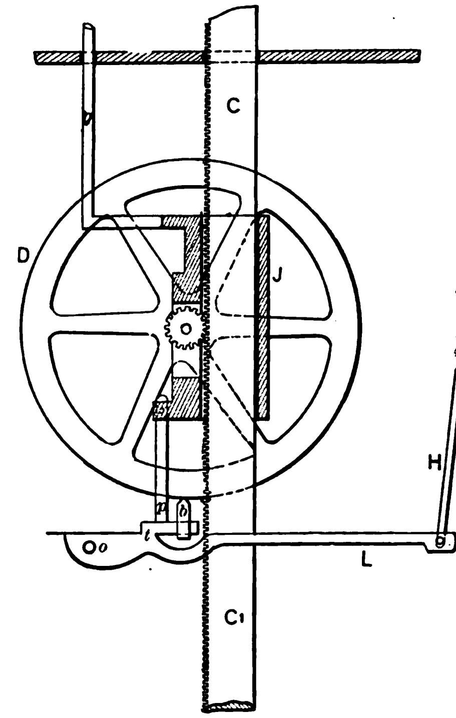


FIG. 18. CROMPTON CRABB D.D.LAMP.

When the lamp is out of action, the free end of the lever is down, and the weight of the wheels and the carbon holder bears down upon the table, *t*, through a pin, *p*, which projects down from the jockey-sleeve. In this position the wheels do not touch the brake-piece, *b*, and are free. When the current is turned on, the main coil of the solenoid attracts its core, first drawing up the lever, which, turning on its pivot as it rises, brings the brake-piece against the rim of the brake-wheels and clamps it. Secondly, the wheels being thus prevented from turning, any further rise of the lever lifts the brake-wheel, jockey, and carbon holder bodily (the weight of them all resting on the brake-piece), thus striking the arc. Thirdly, as the arc burns away, the lever again descends, until, fourthly, when the tail-piece rests on the table and takes the weight off the brake, the feeding begins. There are many other points of interest about this lamp which cannot here be discussed.

Other forms of brake-wheel have been used with success, notably an elastic band-brake, resembling Appold's

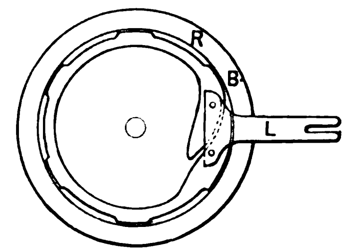


BRAKE-WHEEL OF CROMPTON-CRABB LAMP

FIG. 19.

well-known device, applied outside a smooth wheel, in Statter's lamp [2,985[85]].

The most recent form of clutch-wheel is that devised by Alexander Siemens [6,987[87]], illustrated in figure 20. The lamp to which this device is applied is a holophote lamp for search-lights, with a screw-feed, the screw being turned by this clutch-wheel. It is about one inch in external diameter, and has a projecting rim, R, within which lies an internal metal ring, B, slightly sprung outwards, and cut



SIEMAN'S CLUTCH-WHEEL

FIG. 20.

obliquely, somewhat in the manner of the elastic metal packing rings used in engine pistons. The two ends of this internal split ring are joined, by two pins, to a small lever, L, which projects outwards. When a reciprocating motion, of either large or small range, is imparted to the forked end of this lever, this internal clutch alternately bites against the rim and pushes it forward, and then releases its grip and draws back. This device, which appears to be a really new mechanism, constitutes a true positive feed.

The same device reappears in a recent lamp by Fein [1888] which has a main circuit-magnet striking the arc by drawing down the lower carbon, and a shunt-magnet for feeding, which vibrates an armature by make-and-break arrangement. The upper carbon-holder is smooth, of rectangular section, with a smooth feeding-roller firmly pressed by a spring against it. This feeding roller is attached to a clutch-wheel like figure 20. The lamp lamp will work even upside down. Unlike the clutch-wheel devices previously described, Fein's feed is non-retractile. The latest patterns of clutch-wheel feeds are those of Mackie [7,184^{87}] and Mathis [10,740^{87}]. The advantages of the clutch-wheel mechanisms over the clutches that act directly on the rods, may be summed up

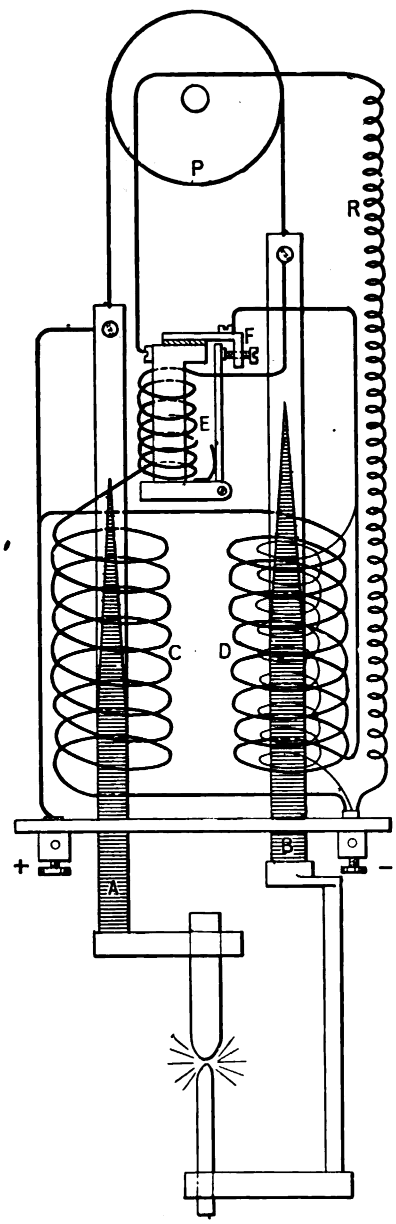


FIG. 21. PILSEN LAMP.

by the remark that they render the operation of the lamp independent of dust and dirt.

Of lamps with *screw-feed* motions the most recent are the projector lamp of Siemens [6,987^{87}] mentioned above, and a motor lamp by Maquaire, which is now being used at the Kensington-court lighting station. In the latter an ingenious and simple method of reversing the motion of the motor armature is adopted, so that both striking and feeding are accomplished by the same screw. This lamp is further described below.

The class of lamps in which cord and pulley mechanism is employed in conjunction with a long range open solenoid, goes back to the early examples of Archerau and Jaspar. In the more complex Pilsen lamp [Krizik and Piette, 1,397^{80}] two solenoids are used, each with its own coned core, the plungers being connected by cord and pulley, and each bearing one carbon pencil. The arrangement of the circuits of the recent form of lamp is shown in figure 21, the core, A, being drawn into the main circuit solenoid, C, to strike the arc, whilst the differentially-wound solenoid, P, varies its pull on the core, B, according as the carbons are required to approach, to stand still, or to recede, the former action occurring when the shunt current prevails. The special cut-out mechanism, E F, will be alluded to later.

A much simpler pattern of lamp has been several times described with various modifications in detail by Jaspar, 1878; Romanze [3,901^{84}], Andrews [3,393^{82}], and lastly by Menges, 1887, whose form is shown in figure 22. Here the long core, S N, is drawn up into the solenoid, wound differentially with a coarse wire, A, and a fine wire winding, B. A heavy piston of metal on the top of the upper carbon holder, *d*, serves both to counterpoise the weight of

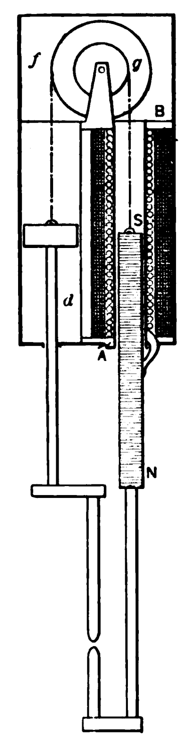


FIG. 22. MENGES.

the core, and to check, as it slides in the surrounding tubes, any too sudden movements. It is often claimed for solenoid lamps that the absence from them of all mechanism renders them superior to all other species of lamps. Yet they are not free from defects; they do not always burn steadily; some of them have the evil habit of "pumping;" and so simple a matter as the elongation of the cord which connects the plungers may put their regulating properties to confusion. In a recent modification by Doubrava the iron cores are fixed, and the solenoid coils slide up and down over them, giving motion to the carbons.

The *screw-feed* lamps have been already touched on. Of these, the most successful in practice is the Cance lamp [3,976^{81}], which operates by the weight of the upper carbon. The screw is prevented from turning by a nut gripped until feeding is necessary. In Siemens's holophote lamp [6,987^{87}], and in Maquaire's new lamp [1889], the mechanical turning of the screw forces the carbons forward.

Amongst *magnetic-clutch* lamps the Gülcher lamp, as improved by the Gülcher company [Whiteman, 1,915^{88}],

still holds its own. In this lamp the single counterpoised horseshoe electro-magnet—with unequal limbs—sticks itself on by one pole to the iron carbon rod, and by the other pole attracts itself upward to strike the arc. For constant potential work it is a very steady lamp. More recently, magnetic clutch-wheels have been used by Dittmar [1886], and by Trott and Fenton [6,910[84]].

Motor lamps have been devised from time to time, those of Tchikoleff, Schuckert, and Gray being perhaps the best until recently. The latest lamp of this type is that of Maquaire [1889]. In this lamp there is a Pacinotti ring upon a vertical pivot, on which a worm is cut. This gears into a large wheel, the pinion of which drives the upper carbon holder by a rack. The motor ring stands between the pole-pieces of a powerful electro-magnet. By rotating it in one direction it strikes the arc; by rotating it in the reverse direction it feeds the arc. The direction of its rotation is reversed by reversing the direction of the current in it. This is accomplished in the following ingenious way. The coils of the electro-magnet are in the main circuit; and from a point midway along these coils a branch wire goes to one of the brushes of the armature. The other brush is connected to the tongue of a sort of relay, and stands between two contacts, one of which goes to one end, the other to the other end of the coils on the electro-magnet. By raising or lowering the tongue the armature is thus connected as a shunt, either to one-half of the magnet coils or to the other, the current in it being in opposite directions in the two cases. The tongue of the relay is controlled by a separate shunt coil, which attracts the tongue in order to feed the arc. The feed action of this lamp is extremely delicate.

(*To be continued.*)

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.[1]

BY G. W. DE TUNZELMANN, B. SC.

(Concluded from page 309.)

The latest researches of Dr. Hertz on electrical oscillations, of which accounts have been published at present are described in a paper "On Electro-Dynamic Waves in Air, and their Reflection," in Wiedemann's *Annalen*, vol. xxxiv., p. 609. The author had been endeavoring to find a more striking and direct proof of the finite velocity of propagation of electro-dynamic waves than those which he had hitherto given, for, though these are quite sufficient to establish the fact, they can only be properly appreciated by one who has obtained a grasp of the results of the entire series of researches.

In many of the experiments which have been described Dr. Hertz had noticed the appearance of sparks at points in the secondary conductor, where it was clear from geometrical considerations that they could not be due to direct action, and it was observed that this occurred chiefly in the neighborhood of solid obstacles. It was found, moreover, that in most positions of the secondary conductor the feeble sparks produced at a great distance from the primary became considerably stronger in the vicinity of a solid wall, but disappeared with considerable suddenness quite close to the wall. The most obvious explanation of these experiments was that the waves of inductive action were reflected from the wall and interfered with the direct waves, especially as it was found that the phenomena became more distinct when the circumstances were such as to favor reflection to the greatest possible extent. Dr. Hertz therefore determined upon a thorough investigation of the phenomena.

The experiments were made in the Physical Lecture Theatre, which is 15 meters in length, 14 meters in width, and six meters in height. Two rows of iron columns, running parallel to the sides of the room, would collectively act almost like a solid wall towards electro-dynamic action, so that the available width of the room was only 8.5 meters. All pendant gas fittings were removed, and the room left empty, with the exception of wooden tables and forms, which would not exert any appreciable disturbing effect. The end wall, from which the waves were to be reflected, was of solid sandstone, with two doors in it, and the numerous gas pipes attached to it gave it, to a certain extent, the character of a conducting surface, and this was increased by fastening to it a sheet of zinc four meters high and two meters broad, connected by wires to the gas pipes and a neighboring water pipe. Special care was taken to provide an escape for the electricity at the upper and lower extremities of the zinc plate, where a certain accumulation of electricity was to be expected.

The primary conductor was the same that was employed in the experiments described in my last paper, and was placed at a distance of 13 meters from the zinc plate, and, therefore, two meters from the wall at the other end of the room. The conducting wire was placed vertically, so that the E. M. F.'s to be considered increased and diminished in a vertical direction. The centre of the primary conductor was 2.5 meters above the floor of the room, which left a clear space for the observations above the tables and benches. The point of intersection of the reflecting surface with the perpendicular from the centre of the primary conductor will be called the point of incidence, and the experiments were limited to the neighborhood of this point, as the investigation of waves striking the wall at a considerable angle would be complicated by the differences in their polarization. The plane of vibration was therefore parallel to the reflecting surface, and the plane of the waves was perpendicular to it, and passed through the point of incidence.

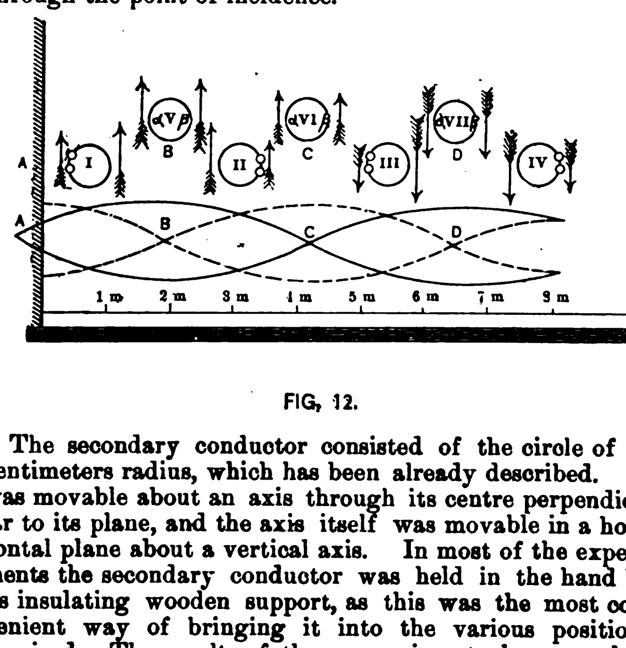


FIG. 12.

The secondary conductor consisted of the circle of 35 centimeters radius, which has been already described. It was movable about an axis through its centre perpendicular to its plane, and the axis itself was movable in a horizontal plane about a vertical axis. In most of the experiments the secondary conductor was held in the hand by its insulating wooden support, as this was the most convenient way of bringing it into the various positions required. The results of these experiments, however, had to be checked by observations made with the observer at a greater distance from the secondary, as the neighborhood of his body exerted a slight influence upon the phenomena. The sparks were distinct enough to be observed at a distance of several meters when the room was darkened, but when the room remained light they were practically invisible even when the observer was quite close to the secondary.

When the centre of the secondary was placed in the line of incidence and with its plane in the plane of vibration, and the air-space was turned first towards the reflecting wall and then away from it, a considerable difference was generally observed in the strength of the sparks in the two positions. At a distance of about 0.8 meter from

1. From the *Electrician* (London).

the wall the sparks were much stronger when the air-space was directed towards the wall, and its length could be adjusted so that while there was a steady stream of sparks when in this position, they disappeared entirely when the air space was directed away from the wall. These phenomena were reversed at a distance of three meters, and recurred, as in the first case, at a distance of 5.5 meters. At a distance of eight meters the sparks were stronger when the air space was turned away from the wall, as at the distance of three meters, but the difference was not so well marked. When the distance was increased beyond eight meters no further reversal took place, owing to the increase in the direct effect of the primary oscillation and the complicated distribution of the E. M. F. in its neighborhood.

The positions i., ii., iii., and iv. (figure 12) of the secondary circle are those in which the sparks were strongest, the distance from the wall being shown by the horizontal scale at the foot. When the secondary circle was in the positions v., vi., and vii., the sparks were equally strong in both positions of the air space, and quite close to the wall the difference between the sparking in the two positions again diminished. Therefore the points A, B, C, D in the diagram may in a certain sense be regarded as nodes. The distance between two of these points must not, however, be taken as the half-wave length, for if all the electrical motions changed their directions on passing through one of these points the phenomena observed in the secondary circuit would be repeated without variation, since the direction of oscillation in the air space is indifferent.

The conclusion to be drawn from the experiments is that in passing any one of these points part of the action is reversed, while another part is not. The experimental results, however, warrant the assumption that twice the distance between two of these points is equal to the half-wave length, and when this assumption is made the phenomena can be fully explained.

For, suppose a wave of E. M. F., with oscillations in a vertical direction, to impinge upon the wall, and to be reflected with only slightly diminished intensity, thus giving rise to stationary waves. If the wall were a perfect conductor, a node would necessarily be formed in its surface, for at the boundary and in the interior of a perfect conductor the E. M. F. must be infinitely small. The wall cannot, however, be considered as a perfect conductor, for it was not metallic throughout, and the portion which was metallic was not of any great extent. The E. M. F. would therefore have a finite value at its surface, and would be in the direction of the impinging waves. The node, which in the case of perfect conductivity would occur at the surface of the wall, would, therefore, actually be situated a little behind it, as shown at A in the diagram. If, then, twice the distance A B—that is to say, the distance A C—is half the wave-length the steady waves will be as represented by the continuous lines in figure 12. The E. M. F.'s acting on each side of the circles, in the positions i., ii., iii., and iv., will, therefore, at a given moment be represented in magnitude and direction by the arrows on each side of them in the diagram. If, therefore, in the neighborhood of a node the air space is turned towards the node, the strongest E. M. F. in the circle will act under more favorable conditions against a weaker one under less favorable conditions. If, however, the air space is turned away from the node, the stronger E. M. F. acts under less favorable conditions against a weaker one under more favorable conditions. In the latter case the resultant action must be less than in the former, whichever of the two E. M. F.'s has the greater effect, which explains the change of sign of the phenomenon at each quarter-wave length.

This explanation is further confirmed by the consideration that if it is the true one the change of sign at the points B and D must take place in quite a different manner from that of the point C. The E. M. F's acting on the secondary circle, in the positions v., vi., and vii., are shown by the corresponding arrows, and it is clear that in the positions B and D, if the air space is turned from one side to the other, the vibration will change its direction round the circle, and, therefore, the sparking must during the rotation vanish either once or an uneven number of times. In the position C, however, the direction of vibration remains unaltered, and therefore the sparks must disappear an even number of times, or not at all.

The experiments showed that at B and D the sparking diminished as the air space receded from a, vanished at the highest point, and again attained its original value at the point β. At C, on the other hand, the sparking continued throughout the rotation, being a little stronger at the highest and lowest points. If, then, there is any change of sign in the position C, it must occur with very much smaller displacements than in the other positions, so that in any case there is a distinction such as required between this and the other two cases.

Another very direct proof of the truth of Dr. Hertz's representation of the nature of the waves was obtained. If the secondary circle lies in the plane of the waves instead of in the plane of vibration, the E. M. F. must be equal at all points of the circle, and for a given position of the air space, the sparking must be directly proportional to its intensity. When the experiment was made it was found, as expected, that at all distances the sparking vanished at the highest and lowest points of the circle, and attained a maximum value at the points in the horizontal plane through the point of incidence.

The air space was then placed at such a point and close to the wall and was then moved slowly away from the wall, when it was found that while there was no sparking quite close to the metal plate, it began at a very small distance from it, rapidly increased, reached a maximum at the point B, and then diminished again. At C the sparking again became excessively feeble, and increased as the circle was moved still further away. The sparking continued steadily to increase after this, as the motion of the circle was continued in the same direction, owing, as before, to the direct action of the primary oscillation.

The curves shown by the continuous lines in figure 12 were obtained from the results of these experiments, the ordinates representing the intensity of the sparks at the distances represented by the corresponding abscissæ.

The existence in the electrical waves of nodes at A and C, and of loops at B and D, is fully established by the experiments which have been described; but in another sense the points B and D may be regarded as nodes, for they are the nodal points of a stationary wave of magnetic induction which, according to theory, accompanies the electrical wave and lags a quarter wave-length behind it.

This can easily be shown to follow from the experiments, for when the secondary circle is placed in the plane of vibration with the air space at its highest point, there will be no sparking if the E. M. F. is uniform throughout the space occupied by the secondary. This can only take place if the E. M. F. varies from point to point of the circle, and if its integral round the circle differs from zero. This integral is proportional to the number of magnetic lines of force passing backwards and forwards across the circle, and the intensity of the sparks may be considered as giving a measure of the magnetic induction, which is perpendicular to the plane of the circle. Now in this position vigorous sparking was observed close to the wall, diminishing rapidly to zero as the point B was approached, then increasing to a maximum at C, falling to a well-marked minimum at D, and finally increasing continuously as the secondary approached still nearer to the primary. If the intensities of these sparks are taken as ordinates, positive and negative, and the distances from the wall as abscissæ, the curve shown by the dotted lines in figure 12 is obtained, which therefore represents the magnetic waves.

The phenomena observed in the first series of experi-

ments described in this paper may therefore be regarded as due to the resultant electric and magnetic actions. The former changes sign at A and C, the latter at B and D, so that at each of these points one part of the action changes sign, while the other does not, and therefore the resultant action which is their product must change sign at each of these points, as was found to be the case.

When the secondary circle was in the plane of vibration the sparking in the vicinity of the wall was observed to be a maximum on the side towards the wall, and a minimum at the opposite side, and as the circle was turned from one position to the other there was found to be no point at which the sparks disappeared. As the distance from the wall was increased the sparks on the remote side gradually became weaker, and vanished at a distance of 1.08 meter from the wall. When the circle was carried further in the same direction the sparks appeared again on the side remote from the wall, but were always weaker than on the side next to it; the sparking, however, no longer passed from a maximum to a minimum merely, but vanished during the rotation once in the upper and once in the lower half of the circle. The two null points gradually receded from their original coincident positions, until at the point B they occurred at the highest and lowest points of the circle. As the circle was moved further in the same direction, the null points passed over to the side next to the wall, and approached each other again, until when the centre was at a distance of 2.35 meters from the wall the two null points were again coincident. B must be exactly half-way between this point and the similar point previously observed, which gives 1.72 meter as the distance of B from the wall, a result which agrees, within a few centimeters, with that obtained by direct observation. Moving further in the direction of C, the sparking at different points of the circle became more nearly equal, until at C it was exactly so. In this position there was no null point, and as the distance was further increased the phenomena recurred in the same order as before.

Dr. Hertz found that the position of C could be determined within a few centimeters, the determinations of its distance from the wall varying from 4.10 to 4.15 meters; he gives its most probable value as 4.12 meters. The point B could not be observed with any exactness, the direct determinations varying from six to 7.5 meters as its distance from the wall. It could, however, be determined indirectly, for the distance between B and C being found to be 2.4 meters, taking this as the true value, A must have been 0.68 meter behind the surface of the wall, and 6.52 meters in front of it. The half-wave length would be 4.8 meters, and by an indirect method it was found to be 4.5 meters, so that the two results agree fairly well. Taking the mean of these as the true value, and the velocity of light as the velocity of propagation, gives as the vibration period of the apparatus 1.55 hundred-millionths of a second, instead of 1.4 hundred-millionths, which was the theoretically calculated value.

A second series of experiments were made with a smaller apparatus, and though the measurements could not be made with as much exactness as those already described, the results showed clearly that the position of the nodes depends only on the dimensions of the conductors and not on the material of the wall.

Dr. Hertz states that after some practice he succeeded in obtaining indications of reflection from each of the walls. He was also able to obtain distinct evidence of reflection from one of the iron columns in the room, and of the existence of electro-dynamic shadows on the side of the column remote from the primary.

In the preceding experiments the secondary conductor was always placed between the wall and the primary conductor—that is to say, in a space in which the direct and reflected rays were traveling in opposite directions, and gave rise to stationary waves by their interference.

He next placed the primary conductor between the wall and the secondary, so that the latter was in a space in which the direct and reflected waves were traveling in the same direction. This would necessarily give rise to a resultant wave, the intensity of which would depend on the difference in phase of the two interfering waves. In order to obtain distinct results it was necessary that the two waves should be of approximately equal intensities, and therefore the distance of the primary from the wall had to be small in comparison with the extent of the latter, and also in comparison with its distance from the secondary.

To fulfill these conditions the secondary was placed at a distance of 14 meters from the reflecting wall, and, therefore, about one meter from the opposite one, with its plane in the plane of vibration, and its air space directed towards the nearest wall, in order to make the conditions as favorable as possible for the production of sparks. The primary was placed parallel to its former position, and at a perpendicular distance of about 30 centimeters from the centre of the reflecting metallic plate. The sparks observed in the secondary were then very feeble, and the air space was increased until they disappeared. The primary conductor was then gradually moved away from the wall, when isolated sparks were soon observed in the secondary, passing into a continuous stream when the primary was between 1.5 and two meters from the wall—that is, at the point B. This might have been supposed to be due to the decrease in the distance between the two conductors, except that as the primary conductor was moved still further from the wall the sparking again diminished, and disappeared when the primary was at the point C. After passing this point the sparking continually increased as the primary approached nearer to the secondary. These experiments were found to be easy to repeat with smaller apparatus, and the results obtained confirmed the former conclusion, that the position of the nodes depends only on the dimensions of the conductor, and not on the material of the reflecting wall.

Dr. Hertz points out that these phenomena, which are exactly analogous to the acoustical experiment of approaching a vibrating tuning-fork to a wall, when the sound is weakened in certain positions and strengthened in others, and also to the optical phenomena illustrated in Lloyd's form of Fresnel's mirror experiments; and as these are accepted as arguments tending to prove that sound and light are due to vibration, his investigations give a strong support to the theory that the propagation of electro-magnetic induction also takes place by means of waves. They, therefore, afford a confirmation of the Faraday-Maxwell theory of electrical action. He points out, however, that Maxwell's, in common with other electrical theories, leads to the conclusion that electricity travels through wires with the velocity of light, a conclusion which his experiments show to be untrue. He states that he intends to make this contradiction between theory and experiment the subject of further investigation.

LOSS IN THE ARMATURE OF SERIES MACHINES.[1]

BY RICHARD OPITZ.

FOLLOWING Professor Dr. Fr. Vogel's treatise on the working of dynamo-electric machines, and with special reference to an old Siemens's drum machine, I would like, at the instance of Professor Vogel, to submit the following notes of experiments and measurements made by me upon a ring machine. The machine was one from Fraas Bros., of Wunsiedel, and was wound in series. Each of the four field magnets was wound with 8½ meters of copper wire, 2 mm. in diameter. The ring had an external diameter of 26 cm., that is $r = 13$; an inside diameter of 12 cm.; and a thickness of 4 cm. The middle of the windings

1. Translated from the *Centralblatt für Elektrotechnik.*

were, therefore, removed from the axle at a distance of

$$\frac{13 + 6}{2} = 9.5 \text{ cm.}$$

The copper windings of the armature consisted of 22 parts, each having 6 layers of 12 windings each, the wire being of 0.9 mm. diameter. The depth of the armature core was 5.5 cm. and its thickness 2 cm. The average length of a turn was 17 cm.; then for the whole armature we have

$$22 \times 6 \times 12 \times 17 = 26{,}900 \text{ cm.} = s,$$

which value we shall need later for determining μ.

The resistance cold was found to be

$$W_t = 3.35 \text{ ohms},$$

although as an average we will take

$$W_t = 3.45 \text{ ohms},$$

since the resistance in one and a half hours running, with a current of 8.7 amperes rose to

$$W_t = 3.55 \text{ ohms}.$$

My experiment was to have been on the plan of varying the position of the brushes, and then determine the iron construction characteristic μ for the current following each change. We found, however, that the various positions of the brushes, produced but little effect in the value of μ. In all my measurements I followed the plan of going from a higher to a lower current.

The direct measurements follow :—

$J.$	$\frac{P_1}{g.}$	$R_1 P_1$ Cm. dyn.	$\mu = \frac{R_1 P_1}{i.\ s.}$	$J.$	$\frac{P_1}{g.}$	$R_1 P_1$ Cm. dyn.	$\mu = \frac{R_1 P_1}{i.\ s.}$	$J.$	$\frac{P_1}{g.}$	$R_1 P_1$ Cm. dyn.	$\mu = \frac{R_1 P_1}{i.\ s.}$
11.1	2750	8088.10^4	5470	7.8	1870	5500.10^4	5246	4.7	950	2796.10^4	4519
10.8	2700	7946. "	5470	7.5	1770	5209. "	5234	4.8	850	2502. "	4428
10.4	2600	7652. "	5470	7.1	1640	4944. "	5251	4.1	790	2325. "	4322
10.2	2500	7357. "	5363	6.8	1590	4679. "	5116	3.7	650	1913. "	3951
9.9	2450	7314. "	5470	6.7	1550	4562. "	5189	3.2	550	1619. "	3761
9.7	2400	7061. "	5470	6.4	1450	4287. "	4957	2.9	460	1354. "	3595
9.2	2200	6475. "	5282	6.2	1400	4120. "	4941	2.4	310	912. "	2826
9.2	2280	6710. "	5428	6.0	1320	3985. "	4814	1.7	210	618. "	2572
8.6	2130	6269. "	5420	5.6	1200	3532. "	4689	1.3	130	383. "	2370
8.4	2010	5915. "	5286	5.3	1150	3385. "	4839	0.7	60	177. "	2188
8.1	1950	5739. "	5384	5.1	1080	3178. "	4726	.0	0	0. "	

These values we will represent in a co-ordinate system, where the abscissas represent current in amperes and the ordinates the corresponding values of $R_1\ P_1$ and μ.

According to Professor Vogel in his development of the theory of dynamo-electric machinery,

$$\mu = \frac{R_1 P_1}{i.\ s.}, \text{ where } i = \frac{J}{2}$$

As a measure of the average intensity of the magnetic field, I take

$$\frac{\mu}{\text{middle radius}} = \frac{\mu}{\frac{i}{s}\int Rds}.$$

For the present machine it is accurate enough to say

$$\frac{i}{s}\int Rds = \frac{13 + 6}{2} = 9.5 \text{ cm.}$$

Table of the values taken from the curves.

J Amp.	$R_1\ P_1$ Cm. dyn.	$\mu = \frac{R_1\ P_1}{i.\ s.}$
0	0	2
1	279.10^4	2015
2	718. "	2785
3	1316. "	3445
4	2146. "	4015
5	3028. "	4465
6	3397. "	4840
7	4785. "	5090
8	5678. "	5285
9	6358. "	5405
10	7335. "	5480
11	8085. "	5495

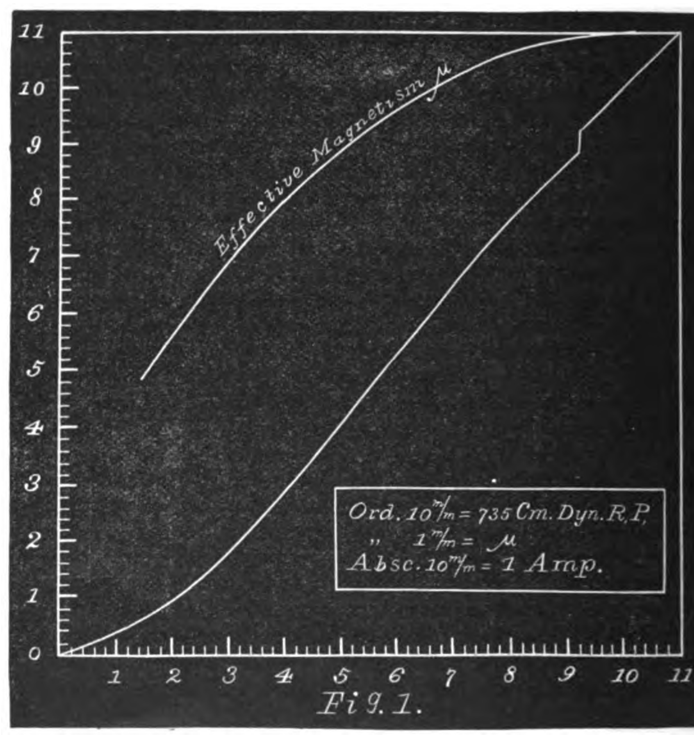


Fig. 1.

For the force P_1 and for the twisting moment $R_1\ P_1$ we have similar curves resembling an hyperbola whose vertex, however, does not fall on the zero of the co-ordinate system.

The curve rises slowly from $J = o$, then from a certain current (with our machine, about four amperes) it rises rapidly in a straight line, approaching infinity with an infinite current.

In practice, this straight part of the curve is by far the most important, and to this I will now turn with a few words.

Professor Vogel gives as the equation for this straight line,

$$R_1\ P_1 = C\ (J - A)$$

where C and A represent constants of the machine, and are only good for a definite position of the brushes—new constants corresponding to every change in this position.

These constants are determined as follows :—

We imagine the straight part of the curve $R_1\ P_1$ prolonged until it cuts the axis of abscissas; then the constant A is the distance of this point of intersection from the zero point. Only two points in this straight part of the curve

are necessary for calculating the theoretical effect of the machine.

If $R_1\ P_1$ and $R_1'\ P_1'$ are two values of the twisting moment for the two currents J and J', then the constant C is given by

$$C = \frac{R_1\ P_1 - R_1'\ P_1'}{J - J'}.$$

We can write for μ

$$\mu = \frac{2\ C}{s} \left(\frac{J - A}{J} \right).$$

The curve of average magnetism working in the room taken up by the windings mounts gradually from a finite value for $J = o$, but always with its concave side toward the axis of abscissas.

In figure 1, the curve at 9.2 ampere shows clearly the effect of a new position of the brushes.

NUMBER OF REVOLUTIONS CONSTANT; CURRENT VARIABLE.

In our equation

$$R_1\ P_1\ 2\ \pi\ n = J\ E;$$

$2\ \pi\ n$ is a constant, provided that the machines preserves the same velocity of revolution. If we again take the current as abscissas, then the curve $J\ E$ has the whole electri-

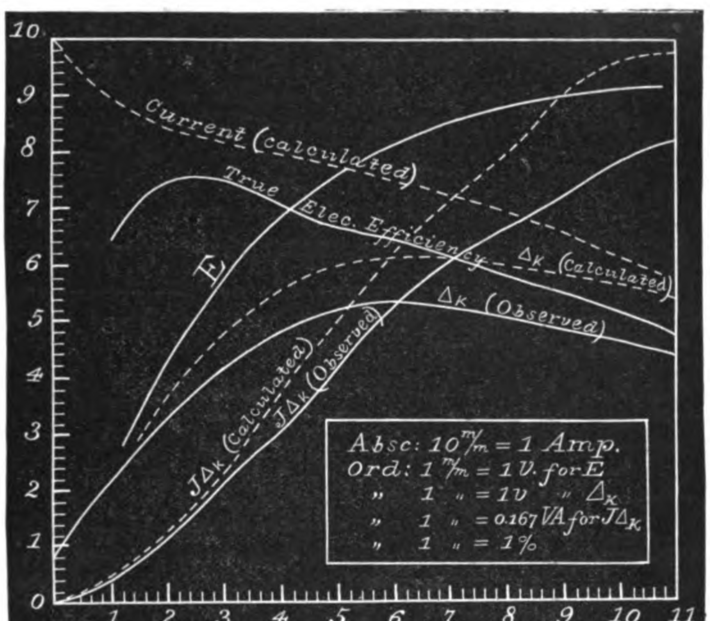


Fig. 2.

cal effect produced; the same character; and the same form as the curve for the twisting moment $R_1\ P_1$.

By transformation, we have as the E. M. F. of the machine

$$\frac{R_1\ P_1\ 2\ \pi\ n}{J} = E.$$

If we again regard this curve, that is the straight part of it, we can after A and C are determined, bring the above formula into use. For the number of revolutions of our machine we have

$$C\ (J - A)\ 2\ \pi\ n = J\ E,$$

from which $E = \dfrac{C\ (J - A)\ 2\ \pi\ n}{J}$.

By subtracting the lost effect from the whole induced electrical effect; and the loss of potential from the E. M. F. we obtain for each J, respectively $J\ \Delta_k$ the external available electrical effect, and Δ_k the terminal potential.

That is:— $\quad J\ E - J^2\ W_t = J\ \Delta_k$

and $\quad E - J\ W_t = \Delta_k$

where W_t is the total resistance of the machine, and when the self-induction in the armature is not regarded.

These two values can easily be obtained from the formula,

$$J\ \Delta_k = C\ (J - A)\ 2\ \pi\ n - J^2\ W_t$$

$$\Delta_k = \frac{C\ (J - A)}{J}\ 2\ \pi\ n - J\ W_t.$$

Table of direct measurements, with constant velocity and variable current.

J	Δ_k	$J\ \Delta_k$	$J\ W_t$	$J\ W_t$	J	Δ_k	$J\ \Delta_k$	$J\ W_t$	$J\ W_t$
A.	V.	V. A.	V. A.	V.	A.	V.	V. A.	V. A.	V.
0	9.6	0	0	0	7.4	50.9	376.7	188.9	25.5
3.0	42.5	127.5	31.1	10.4	7.6	50.5	383.8	199.3	26.2
3.9	48.5	189.3	52.5	13.5	7.8	50.1	390.8	209.9	26.9
4.5	49.7	223.7	69.9	15.5	7.9	49.8	393.4	215.3	27.3
4.7	50.1	235.5	76.2	16.2	8.2	49.0	401.8	232.0	28.3
5.2	51.4	267.3	93.3	17.9	8.6	49.0	421.4	255.2	29.7
5.4	51.9	280.3	100.6	18.6	8.8	49.0	431.2	267.2	30.4
5.8	52.2	302.8	116.1	20.0	8.9	49.0	436.1	273.3	30.7
6.1	53.5	320.3	128.4	21.1	9.3	48.5	451.0	298.5	32.1
6.4	52.8	337.9	141.3	22.1	9.6	48.2	463.2	318.0	33.1
6.6	52.5	346.5	150.3	22.8	9.8	47.6	468.4	331.3	33.8
6.7	52.4	351.1	154.9	23.1	9.9	46.5	477.7	338.1	34.2
6.8	52.2	355.0	159.5	23.5	10.4	45.9	481.2	373.1	35.9
6.9	52.2	359.0	164.3	23.8	10.5	45.4	483.6	380.4	36.2
7.0	51.3	359.1	169.1	24.2	10.7	45.1	484.7	394.1	36.9
7.1	51.3	364.2	173.9	24.5	10.9	44.8	490.6	409.9	37.6
7.4	51.0	377.4	183.9	24.5	11.2	44.2	485.7	432.8	38.6

In order to make the curves plainer, I have drawn the "calculated" ones dotted, and those actually "observed," full. After representing the curves in a co-ordinate system, the following tables are made up from data taken direct from the curves themselves.

J	$J\ E$	E	$J^2 W_t$	$J\ W_t$	$J\ \Delta_k$		Δ_k		App. resist.	Electrical efficiency.	
					Cal.	Obs.	Cal.	Obs.		Cal.	Obs.
A.	V. A.	V.	V. A.	V.	V. A.	V. A.	V.	V.	Inc. ohms.	%	%
0	0	?	0	0	0	0	0	9.6	?	100.	?
1	33.9	33.91	4.5	3.45	29.4	30	30.46	21.0	1.89	89.8	61.9
2	84.8	42.41	15.6	6.90	69.2	74.	35.51	32.0	1.75	83.7	75.5
3	169.0	56.53	31.1	10.4	137.9	127.5	45 92	42.2	1.34	81.5	74.9
4	275.1	68.77	55 2	13.8	219.9	190.8	54.97	48.5	1.62	78.1	70.5
5	383.4	76.69	86.0	17.25	297 4	244.5	59.44	51,3	1.62	77.5	66.9
6	489.8	81.64	123.8	20.75	366.0	317.5	60.89	52.4	1.41	74.6	64.2
7	596 3	85.19	169.1	24.2	427.2	359.1	60.99	51.6	1.33	73.3	62.0
8	699.0	87.37	220.0	27.6	479.0	398.0	59.77	49.9	1.26	68.4	57.1
9	814.9	90.54	278.4	31.1	536.5	436.0	59.77	48.4	1.23	65.7	53.5
10	907.6	90.76	345.5	34.5	562.1	476.0	56.21	46.9	0.95	61.9	51.7
11	1000.3	90.94	418.0	37.9	583.8	487.0	53.0	44.6	0.76	58.3	49 0

The difference between the calculated and the observed values is always the loss in the machine caused in the passage of the commutator strips under the brushes.

From the curve for the electromotive force E we see that it rises from a finite value for $J = o$ and approaches a maximum; it has the same form as the curve for μ, as besides μ the curve E has but one other constant factor, that is to say:—

$$E = \mu\ s\ \pi\ n$$

With the external circuit open, the electrical effect $J\ \Delta_k$ will be o when $J = o$; in the same manner by short circuited machine, that is when $\Delta_k = o$.

Theoretically the electrical efficiency for $J = o$ should be 100 per cent.; we see, however, both by the calculation and by the curve, that a part of the potential is lost.

CONSTANT CURRENT; VARIABLE VELOCITY.

With constant current, the twisting moment is the same; that is $R_1\ P_1 = 2\ \pi\ n = J\ E$, the whole electrical effect produced.

If now for abscissas we take our n's, we will then have for the curve $J\ E$ a straight line passing through $o.\ o.$ We keep

J, however, constant; then it follows from our primary equation that the E. M. F. is also proportional to the revolution, and here again is the curve a straight line.

In this series of experiments, of course, the "maximum" position of the brushes, and the average working magnetism remained unchanged. Since the current is unchanged, so is also constant the loss effect $J^2 W_t$ (depending upon the metallic resistance of the machine) and the loss of potential $J W_t$, when the machine after having run for a certain length of time comes to a stationary condition as regards temperature; that is, when just as much heat is radiated and conducted off as is generated.

Since $J \Delta_k$ and Δ_k are respectively the available electrical effect and the potential at brushes, which, as we saw above, could be obtained from the differences:—

$$J E - J^2 W_t = J \Delta_k$$

and

$$E - J W_t = \Delta_k$$

we may conclude that in order to induce the current J also by short circuited machine, a certain number of revolutions n_o, "the dead turns" are necessary for a definite current. When $n = n_o$, then $\Delta_k = o$ and the external resistance $\frac{\Delta_k}{J} = o$.

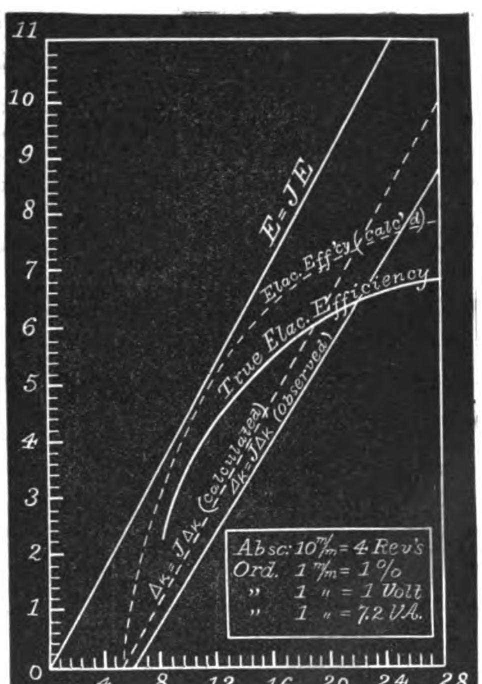


Fig. 3.

The curve for Δ_k forms a straight line parallel to E, and passes through a definite point in the axis of abscissas.

In the above case, for 7.2 amperes,

$$R_1 P_1 = 5048.10^4 \ cm. \ dyn.$$

Table of direct measurements with constant current; variable velocity.

Revols. per min.	n Sec.	J A.	Δ_k Obs. V.	Δ Cal.	$J E$ V.A.	E V.	$J^2 W_t$ W. A.	$J W_t$ V.	$J \Delta_k$ Obs.	$J \Delta_k$ Cal.
1720	28.67	7.2	89.9	101.5	908.9	126.3	178.8	28.8	647.3	730.1
1515	25.25	"	77.0	86.6	802.1	111.4	"	"	554.4	623.3
1213	20.22	"	52.7	64.4	642.3	89.2	"	"	379.4	463.5
1020	17.00	"	41.4	50.2	540.1	75.0	"	"	298.1	361.3
883	14.72	"	32.9	40.1	467.6	64.9	"	"	236.9	288.8
835	13.92	"	29.7	36.6	442.2	61.4	"	"	213.8	263.4
570	9.5	"	14.2	17.1	301.8	41.9	"	"	100.8	123.0
483	8.08	"	7.04	10.6	255.1	35.4	"	"	50.7	76.3
403	6.72	"	1.9	4.9	213.5	29.7	"	"	13.7	34.7

The following table shows the values of the direct measurements, which, after having been represented in a co-ordinate system, are taken from the curves at intervals corresponding to increase of two revolutions.

The difference between $J \Delta_k$ and Δ_k "calculated" and "observed" gives the loss in the machine through self-induction. The electrical efficiency for every value of n is equal to the ratio of the ordinates $\frac{J \Delta_k}{J E} = \frac{\Delta_k}{E}$

Table from the curves; for every two revolutions constant, 7.2 amperes. 5048 × 10⁴ cm. dyn.

n	E V.	$J E$ V. A.	$J^2 W_t$ V. A.	$J W_t$ V.	$J \Delta$ Cal. V. A.	$J \Delta$ Obs. V. A.	Δ_k Cal. V.	Δ_k Obs. A.	App. resist. Inc. ohms.	Electrical efficiency. Cal. %	Electrical efficiency. Obs. %
0	0	0	178.8	24.8	..	....	..	.	...	....	....
2	8.8	63.4	"	"	....	.	....	...	....	....	...
4	17.6	126.7	"	"	....	. .	...	....	....	....	. ..
6	26.5	190.8	"	"	13.7	....	1.9	...	...	7.2	....
8	35.4	254.9	"	"	76.3	51.8	10.6	7.2	0.47	29.9	20.3
10	44.5	320.4	"	"	139.0	108.7	19.3	15.1	0.58	43.4	33.9
12	53.8	[illegible]	"	"	201.6	164.9	28.0	22.9	0.71	52.5	43.0
14	62.0	446.4	"	"	265.0	222.5	36.3	30.9	0.81	59.3	49.8
16	71.2	[illegible]	"	"	327.6	280.8	45.5	39.0	0.90	63.9	54.8
18	80.4	578.9	"	"	391.7	338.4	54.4	47.0	1.02	67.7	58.4
20	89.5	644.4	"	"	455.0	396.7	63.2	55.1	1.13	70.6	61.6
22	98.8	711.4	"	"	519.1	453.6	72.1	63.0	1.27	73.0	63.8
24	107.9	776.9	"	"	584.6	512.6	81.2	71.2	1.39	75.3	65.9
26	116.8	841.0	"	"	648.7	572.4	90.1	79.5	1.47	77.1	68.1
28	125.2	901.4	"	"	711.4	627.8	98.8	87.2	1.61	78.9	69.6

From the "dead" turns on, the potential at the brushes increases in proportion to the increase in the number of revolutions, and are not directly proportional to the revolutions themselves.

CONSTANT EXTERNAL RESISTANCE; VARIABLE VELOCITY.

The theoretical behavior of the machine by constant external resistance will be seen when we bring the equation $R_1 P_1 2 \pi n = J E$ in this form:—

$$R_1 P_1 2 \pi n = C (J - A) 2 \pi n = J^2 (W_A + W_t);$$

or,

$$\frac{W_A + W_t}{2 \pi n} = \frac{C (J - A)}{J^2}$$

where W_A is the external resistance.

We have then, for J for any current and any n, a quadratic equation, of which, however, only one value of J can be used. The comparison between constant and variable velocity appears to me to be of but theoretical worth.

From this investigation I come to the conclusion that the behavior of electrical machines, with especial reference to their armatures, is approximately the same for every type and every system, as my work, which was founded upon the theoretical development of Professor Vogel, shows a striking conformity in every respect with the measurements and results of that gentleman, to whom I here express my devoted thanks for his friendly help.

Electrotechnisches Laboratorium,
Braunschweig, 1889.

DESCRIPTION OF PERRET MOTORS AND DYNAMOS.

The chief distinctive feature of these machines, manufactured by The Elektron Mfg. Co., is the method of constructing the field magnet whereby the well-known advantages due to lamination and to the best quality of iron are secured, while the cost, which has heretofore been a bar to the commercial use of such magnets is reduced nearly to that of forgings. This method of construction is peculiarly adapted to machines of small size, and by its use their efficiency is greatly increased, as a test will show. It may also be used to advantage in machines up to 10 h. p. and even higher, as by the ingenious shape

and arrangement of the plates a magnet of large size may be built up of comparatively small plates which are stamped from sheet iron, no other machine work being necessary. Eight sizes ranging from $\frac{1}{16}$ to 2 h. p., are now on the market. Other sizes are in preparation.

In the $\frac{1}{16}$th, $\frac{1}{8}$th and $\frac{1}{6}$th h. p. sizes, a magnet of the ordinary U shape is used in which the plates are so formed and put together that the limbs may be swung apart and clamped to the face plate of a lathe for winding, after which they are swung back and bolted fast.

Figure 1 shows one of these motors complete. Figure 2 shows the magnet before winding.

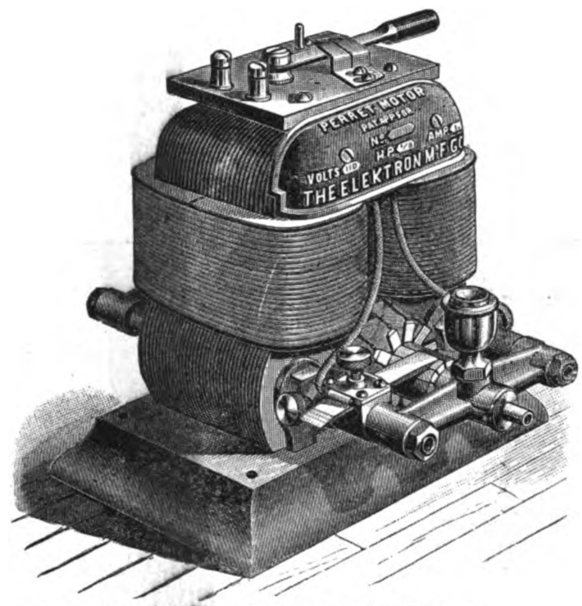


FIG. 1.—Perret Motor under ¼ h. p.

In machines of $\frac{1}{4}$ h. p. and upwards, the double horseshoe shape with consequent poles is used. These are shown in figure 3. Upon removing the two bolts which pass through the yokes, the top half of the magnet may be separated from the lower half. Each half is then attached to a lathe or other suitable machine and wound by revolving it, after which they are put together and the bolts replaced, all these operations being very simple and very rapidly done.

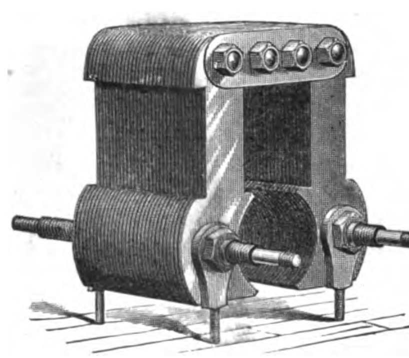


FIG. 2.—Perret Motor, Field Core and Poles.

The plates of which these magnets are built are shown in figure 4. It will be noticed that the plates interleave at the yoke, at which point their cross-section is enlarged and they are clamped firmly together by bolts. Little or no magnetic polarity is found at the yoke, which shows that the joint is good.

An important feature is the extremely low resistance of the magnetic circuit, which is due partly to superior quality of iron, the use of which is allowed by this construction, and partly to the smallness of the air gap between the pole-pieces and the iron of the armature, which is of the drum type, with teeth. In the longitudinal recesses formed by these teeth the armature coils are wound.

This construction *increases the efficiency*, allows a large *reduction in armature speed*, and *improves the regulation*. As showing this, reference is made to the $\frac{1}{2}$ h. p. machine (figure 3), which weighs complete with pulley, 70 pounds, and has a commercial efficiency of 80 to 85 per cent. As a shunt wound dynamo it will generate a current of four amperes at 110 volts when run at a speed of 1,800 revolutions per minute.

The armature is wound with 7,000 inches of conductor, which is at the rate of about 64 inches per volt at the remarkably low peripheral speed of 1,500 feet per minute. This showing we believe to be rarely equaled in machines of the largest size.

It may further be stated of the $\frac{1}{2}$ h. p. machine, that the drop in electromotive force when run as a dynamo, and the variation in speed as a motor, are less than five per cent., between full load and no load. (See details of Prony brake test.)

The motors are usually shunt-wound, and on constant potential circuits run at practically a constant speed, regardless of changes in load. In several instances parties requiring regulation so close that they believed compound

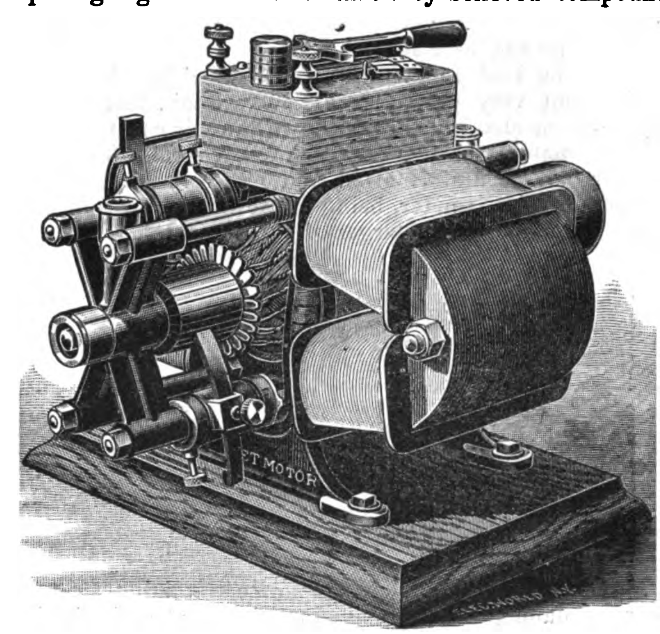


FIG. 3.—Perret Motor ¼ h. p. and upwards.

winding absolutely necessary, have been induced to try the Perret shunt-wound machines, and have found them to fully meet the requirements.

This superior regulation is due to the fact, not always given its full weight, that the regulation of a shunt-wound machine depends not only on the internal resistance of the armature coils, but also to an equal, if not larger degree on the intensity of the field. In other words, the lower the internal resistance of the armature coils, and the lower the resistance of the magnetic circuit, the closer the regulation.

This is clearly demonstrated by recent experiments with a $\frac{1}{8}$th h. p. motor on a 110 volt circuit, which with an armature without teeth, the air gap being $\frac{1}{16}$th of an inch and the internal resistance 11 ohms, showed a variation in speed of 15 per cent. between no load and full load, while with an armature having teeth by which the air gap was reduced to $\frac{1}{32}$ds of an inch, but with the internal resistance of armature increased to 20 ohms, showed a speed variation of only 11 per cent. The same thing is shown by the performance of the $\frac{1}{2}$ h. p. dynamo cited above and also by the Prony brake test of $\frac{1}{2}$ h. p. motor shown herewith.

It is of course not claimed that the use of toothed drum armatures is new, but Mr. Perret finds that they possess some decided advantages over plain armatures in addition

to those already stated, as for instance, positive driving of the coils secured by winding them in the recesses; also he finds that when used with finely laminated field magnets they are free from some disadvantages experienced in other constructions. It is quite certain that such armatures running in close proximity to solid pole-pieces would produce heating effects therein which would be wasteful and very troublesome, to say the least. With laminated field magnets all trouble of this sort is avoided.

A strong point in favor of these machines is freedom from sparking at the commutator, provided this is kept in reasonably good condition, and the brushes having been once set at the non-sparking point require no changing under extreme changes in load. A rocker arm for the brush-holders is therefore unnecessary, and the machine is by so much the simpler. The reason for this will be readily seen by electricians in the foregoing description, and lies in the fact that the magnetism of the field is so powerful relatively to that of the armature that no distortion of the lines of force is produced, and consequently the line of commutation remains unchanged regardless of changes in load.

A prominent electrician, connected with another motor company, was heard to remark after testing some of these machines, that they were "harder to knock a spark out of than any he had ever seen."

It may be said further that these machines have been worked out very perfectly in every detail, and a high degree of mechanical skill is shown in their construction.

The armature shafts are of high grade steel. The bearings are all accurately fitted and are very long in proportion to their diameter, being in the smaller sizes of hard composition, and in the larger of babbitt-metal.

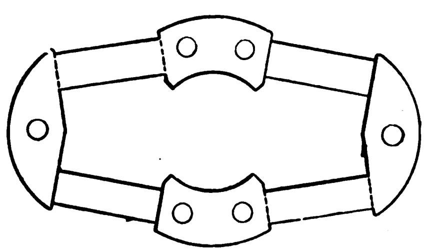


FIG. 4.

The commutators, which ordinarily are liable to great wear and damage, have received particular attention, being made of a special hard bronze.

All the motors are provided with switches for starting and stopping, and in the larger sizes the switches are provided with resistance coils, an arrangement which is much handier than a separate rheostat.

In respect to simplicity they are excelled by none, all parts needing attention being in plain sight and easily accessible. The armatures may be removed for inspection or any other purpose and replaced in running order in less than one minute. All parts are made to standard gauges, and are interchangeable.

Details of Prony brake test of one-half horse-power Perret motor.

Brake h. p.	Speed.	Commercial efficiency.
.146	2050	.73
.185	2048	.74
.219	2046	.745
.250	2044	.76
.290	2042	.77
.320	2040	.78
.365	2035	.79
.400	2030	.80
.432	2024	.81
.467	2018	.815
.501	2010	.82
.535	2000	.80
.569	1995	.78
.600	1990	.76

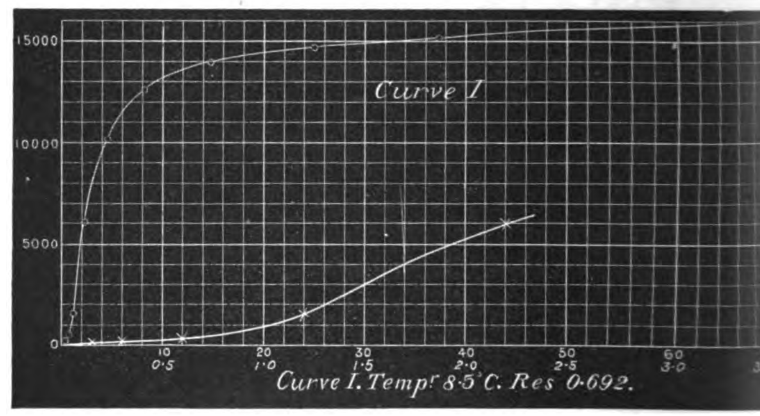
ABSTRACTS AND EXTRACTS.

"MAGNETIZATION OF IRON AT HIGH TEMPERATURES."

BY J. HOPKINSON, F. R. S.

I HAVE recently been making some determinations of the curves of magnetization of iron at varying temperatures up to that at which the iron ceases to be magnetic. Although the experiments are still progressing, some of the results are of sufficient interest to be worth publishing briefly at once.

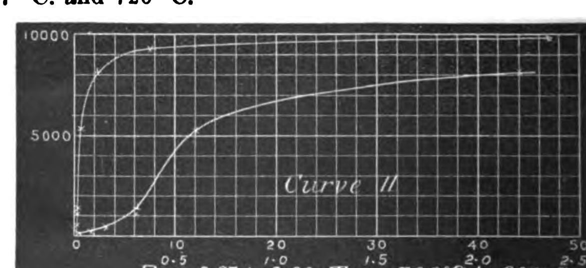
The method of experiment was identical with that which I used for a sample of nickel about a year ago. The temperatures are estimated by the resistance of a copper secondary coil, and as there may be some uncertainty as to what temperatures the several resistances correspond with, I give in the curves which follow the resistance observed as well as the temperature estimated.



Curve i shows the relation of induction to magnetizing force at the ordinary temperature, the resistance of the secondary coil being 0.692 ohm. The curve is given to two scales, the scale of induction being the same in each, whilst the scale of magnetizing force is magnified twenty-fold in the one as compared with the other.

Curve ii shows the same relation for a temperature of 697° C. to 700° C.

Curve iii shows the same thing for a temperature between 727° C. and 720° C.



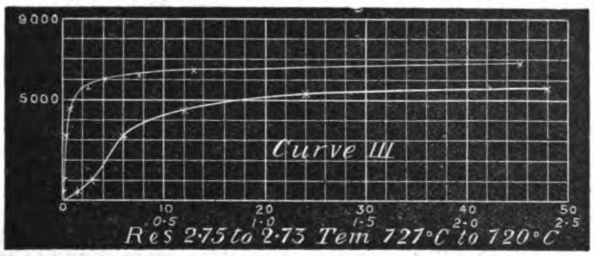
These curves illustrate what has been long known, that rise of temperature causes increase of induction if the magnetizing force is small, but diminution of induction if the force is great.

In curve iv the abscissæ are temperatures, the ordinates are the ratios of induction to magnetizing force or permeabilities for a force of 4.0, and of 0.3 C.G.S. units, the data being supplied from the preceding and other curves. The latter curve brings out a most remarkable feature. For this force the permeability increases somewhat steadily to a temperature of about 640° C., its rate of increase then rapidly accelerates, till it attains a maximum of 11,000 at a temperature of 727° C.; at 737° C. the permeability is

1. From the Proceedings of the Royal Society, vol. 45. (Preliminary Notice. Received January 30, 1889.)

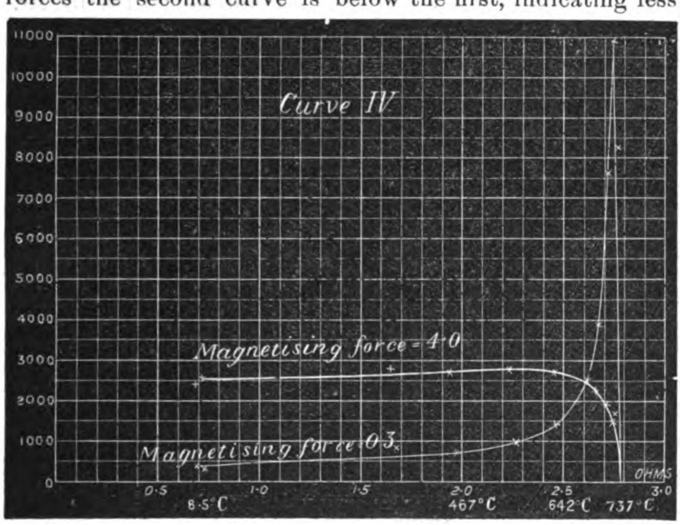
practically unity, or the magnetizability of the material has entirely disappeared.

Regarding the iron as made up of magnetic molecules, the axes of which are directed to parallelism by magnetic forces, the results are expressed by saying that the magnetic moment of the molecule diminishes with rise of temperature, at first slowly, but very rapidly as the point is approached at which magnetism disappears; on the other hand, the facility with which the particles are directed continually increases, at first slowly, but at high temperatures very rapidly. The effect is, that at a temperature of 720° C., an exceedingly small force is competent to turn the axes of nearly all the molecules in a direction parallel to the magnetizing force.



The estimates of temperature given herein must be accepted as provisional and subject to revision. The actual temperatures are undoubtedly materially higher, as I have not yet taken into account the part of the secondary wire outside the furnace.

[If an iron ring which has never been magnetized has its curve of magnetization determined for an ascending series of forces, if it be then thoroughly demagnetized by a succession of reversed currents of descending intensity, and the curve of magnetization is re-determined, I find that the two curves differ materially. The demagnetizing currents do not reduce the iron to its virgin state. For small forces the second curve is below the first, indicating less



induction for the same magnetizing force; for medium forces the second curve is above the first, whilst for large forces the two curves agree.

If a ring be heated with a current through the primary coil, and the heating be continued till the ring has ceased to be magnetic, if then the current be stopped and the ring be allowed to cool, I find that the ring is not entirely demagnetized by the heating, but that it re-collects its state of magnetization before heating. It would seem that the magnetic molecules of the iron, having been directed by the magnetizing force whilst they were magnetic, retain in part their direction when they have ceased to be magnetic by heating, and that when they again become magnetic by cooling its effect is apparent.—February 14, 1889.]

I have tested a sample of manganese steel, and find that at no temperature above the normal temperature does it become substantially magnetic.

SOME RECENT ELECTRICAL WORK ON THE ELEVATED ROADS, AND ITS BEARING ON THE RAPID TRANSIT PROBLEM.[1]

BY LEO DAFT.

MR. DAFT began his paper by premising that, although the demand and need of further or better transit facilities for New York is undoubted, yet, all things considered, New York has even to-day a better rapid transit system than any other city in the world. One may enter a well appointed car at the Battery, travel through the best atmosphere of the city and be carried comfortably to Fifty-ninth street in 26 minutes, or at the average speed of 12 miles an hour, including stops. The elevated roads carry one-half million passengers per diem for a lower rate of fare than is charged in any other city for similar service, and with a smaller proportion of accidents than can be found on any steam road in the world, making an equal number of stops for distance run. It is exceedingly improbable that any steam motor can be devised that will meet the increasing need of still greater service on the existing structures without subjecting them to quickly destructive strains.

Mr. Daft thought that he would be able to produce at least some evidence, that, owing to certain peculiarities not yet satisfactorily explained, an electric motor may be made capable of solving the problem, so far as the ultimate strength as the present elevated structure will permit. The peculiarities alluded to certainly do increase the tractive power beyond the values authoritatively employed in railroad calculations.

That the co-efficients of traction generally employed are not absolutely trustworthy appears in the hesitancy with which they are treated by standard authors, and from the varying co-efficients found in use by practical men under like conditions. This is noticeable to the extent of nearly twenty per cent.—*vide* D. K. Clark and A. M. Wellington. Mr. Daft would not, therefore, pretend to great precision on this point, but to quote an extreme case would go back so far as 1882, to the first series of experiments in which this increased tractive capacity was observed and carried to its apparent maximum.

In experiments with small motors at the works of the Daft company, at Greenville, N. J., in 1882, he constructed an adjustable incline upon which a small motor was caused to ascend a gradually increasing gradient until the extraordinary rise of 2,900 feet per mile (54.9 per cent.) was reached. Up to this point the motor, weighing 450 lbs., plus a man weighing 150 lbs., total 600 lbs., was readily started from a position of absolute rest at the bottom, and ascended the gradient, being occasionally stopped midway and started again with perfect ease. When this final gradient was reached, however, the ascension was less easy and certain, though it was accomplished several times; but attempts to exceed it failed; this was regarded as the maximum under those circumstances. From these experiments Mr. Daft deduced by figures considerably more than double the ultimate working limit of adhesion under the most favorable condition cited by Wellington in the work already quoted.

A prominent engineer in dismissing the idea of increased traction due to the passage of a current between the adhesive surfaces assumes that the effect would be precisely the reverse, and cites the case of the lessened friction between the metallic points and the cylinder of chalk in a well-known instrument; but there is an entire absence of any proper analogy between these two cases. Apparently the motor should not have ascended this gradient—indeed, out of respect for such authorities as Messrs. Clark and Wellington, it ought to have stopped at the bottom of the gradient, meekly rotating its wheels, but the indisputable fact is that it did go up and did it every day, although many gentlemen, among whom were mechanical engineers, could not account for that state of things at all—and no more could Mr. Daft.

The author did not pretend to assert that electric adhesion could be increased to a similar extent in a large locomotive under the conditions of ordinary practice, being fully aware from subsequent experiments that the effect in this instance was due to a very large current of low potential passing through the contact-areas of wheels only one foot in diameter upon a light sixteen-pound rail; but thought the effect undoubtedly obtainable to the extent of 30 per cent. under the ordinary conditions of railroad practice.

An eminent authority some three or four years ago emphatically declined to admit the existence of this effect and, strongly advocating a multiple motor system, declared that increased weight was the only means of increasing the tractive ability of the motors. It was a pleasure to observe that in a later paper the validity of the effects discovered and strenuously insisted upon early in 1883 by Mr. Daft had been acknowledged by the same authority.

Lest any misunderstanding should exist as to the object of the series of tests on the elevated roads, the author would say that the electric motor was not expected to solve the problem by towing

1. Abstract of paper read before the American Institute of Electrical Engineers, New York, June 25, 1889.

longer trains at higher speeds than are at present attained. It was simply to show that a machine weighing little more than one-half the present motors would equal, or nearly equal, their performance in that respect, and, while it is admitted that in acceleration on the heavier gradients the steam motors still show somewhat greater ability, the result of the tests indisputably proves that, with electric motors of the same weight as that of the steam motors now employed, trains of at least six cars on the Ninth avenue, and seven to eight cars on the Sixth avenue, may be propelled at a considerably higher average speed than at present, and when the absence of reciprocating parts is taken into account, the advantage on the side of the electric motor in lessening the destructive strain on the structure, will form an important factor in the economy of operation. That the absence of this destructive strain is no idle dream of the mechanical engineer has been fully realized by many competent observers of the electric trains, since it has been a subject of general remark that the noise of the electric train is merely that inseparable from the rolling of the wheels over the track, the motor itself making no more noise than one of the cars in tow.

Before proceeding to a review of the actual accomplishment, Mr. Daft would briefly describe the electric motor used in question. The "Ben Franklin" consists of a frame having two driving wheels, coupled by discs outside of the bearings with two cast steel cut-split gears mounted on the back axle, and an electric motor pivoted on pedestals at the rear of the cab and supported on similar pedestals with a screw adjustment for raising the whole machine to remove the armature, and wrought steel pinions in nearly vertical engagement with the gears. It is evident that a considerable degree of resilience is not permissible with such an arrangement, but a sufficient amount to prevent excessive rigidity in working is obtained by placing alternating plates of rubber and iron in the pedestals above and below the bearings. A similar arrangement at the driver-bearings cushions the machine without interfering with the mesh to an appreciable degree.

Before the motor was placed in the cab a few Prony brake tests of its ultimate ability were made, resulting in the development of 128 h. p.

The piece of track upon which the experiments have been conducted is eminently adapted for testing the tractive ability of a motor, since there is only one level portion, 2,200 feet in length, the rest, embracing a distance of 1,846 miles, consisting of gradients varying between 11.3 and 98.7 feet per mile, and in one instance, namely, at Thirtieth street, the start is made only a few feet from the bottom of a 98.7-foot gradient.

In October last, experiments were begun (they were made from 9 o'clock at night until 4 o'clock in the morning), and the first experiment consisted in taking a light load of one or two cars over the section to test the conductor and switch connections. This train was gradually increased night after night until one of eight Ninth avenue cars, each weighing 12 tons, was towed over the entire section, going up the 98.7 foot grade at a speed of 7½ miles per hour and making the entire distance in 7 minutes 35 seconds, or an average speed of 14.6 miles per hour. Although a drizzling rain prevailed and the rails slippery there was an entire absence of slipping. It was unfortunate that at the time of this experiment no dynamometer was used, but taking the ordinary co-efficient of rolling friction for a light train of this kind, namely, .004, and assuming the grade resistance to be at the same rate per cent. of the total weight of the train as the rate per cent. of the grade, the rate per cent. of the grade being 1.86, we get the following, $\frac{1.86 \times 4,781 \times 660}{33,000} = 95.8$ h. p., to which should be added at least 15 per cent. for friction and a so-called "head resistance" of the motor, equal to 14.37, or a total of 110.17 h. p. at the power station. The maximum velocity obtained by that train on the level in passing Twenty-third street was 24 feet per second, or 16.36 miles per hour.

These tests were continued for several weeks at intervals of two or three days. The only repairs or delays during all these and subsequent tests were two; once when a coil had to be removed on account of a cross contact (causing a delay of one night), and the other when an axle wore a hole through the insulation of an end coil (causing a detention of fifteen minutes).

Mr. Daft thought he was entitled to say that these results, which were, of course, carefully watched by the Manhattan railway officials, led to a permission to run in the daytime between steam trains—a permission which certainly would not have been granted on a road which has a world-wide reputation for its almost military discipline and precision of management, if the motor had not earned the right to some confidence. On the 28th day of January, 1889, he began running between the hours of 11 and 2 in the day time, continuing with a three-car, and occasionally four-car, express train until the 12th day of February, when he was requested to take a train of flat cars loaded with iron, to the weight of an average four-car train with 75 to 100 passengers, in lieu of the light train formerly employed. With this train, weighing in all 70 tons, he made several trips over the road between the ordinary steam trains, but finding the brakes hardly trustworthy for such critical work, with trains only three minutes from us on either side, it was decided to discontinue this service and a four-car Sixth avenue train was substituted. With this train several trips were made, but in consequence of the absence of air-brakes it was not considered advisable to proceed with the ordinary "stop run," and the remainder of the work was done at night.

A number of experiments made about this time show that the mean speed, with a three-car empty train, running express, on the up-town track, was about 23 miles per hour, though on the level the ability of the motor with a similar train is nearly 28 miles per hour. This is by no means the limit of speed, for tests showed that acceleration was still in progress when the gradient at Twenty-fourth street was encountered. For prudential reasons it was not deemed well to push this matter of speed to its extreme limit.

It does not seem necessary that a greater speed than 30 miles per hour should be attained in the city limits (by express trains) to meet all the requirements of rapid transit, and when the great power required for the accelerative effort between the frequent stations, and with the comparatively heavy trains on the Sixth and Third avenues, is taken into account, it is extremely improbable that this speed will ever be exceeded between stations.

Referring to the methods adopted in making measurement, it should be noted that wherever any doubt existed as to the effect of the personal equation in the observations, changes were made in the observers and the experiments repeated so as to leave scarcely a possibility of material error; and in order that the always objectionable average statement should not contribute to confuse the result, the tables were taken from a number of similar ones, which, after careful examination, were found to most fairly represent the mean effects.

In order to measure the speed with sufficient accurary for all practical purposes, the track was divided into nineteen sections of 500 feet, each section being provided with a thin copper plate attached to the guard rail at the side of the track and connected with a copper rod or insulated side of the conductive system. A copper brush attached to the motor in such a manner as to travel on the top of the guard rail was connected with one terminal of a chronograph. This instrument was carefully tested and the results verified by experiments before the readings were accepted. The indicator cards were taken at the central station by Mr. Idell and his assistants, after a careful comparison of watches, so as to insure synchronism in observing the effects of acceleration and gradients. The dynamometer used was a fine specimen of the liquid type, owned by the Manhattan railway and made by Mr. Shaw, of Philadelphia; and after careful calibration by Mr. Shaw and Mr. Idell was found to be accurate within an inappreciable amount. The dynamometric readings have been omitted from the tables for the reason that they were found to throw so much light upon the ordinarily accepted co-efficients of train resistance, under many of the conditions which the text-books have not yet considered, and especially the formulas relating to the subject of acceleration, that time would not permit a thorough digest of the results.

The tests showed that in the run of a two-car express train, having a total weight of 40 tons, the initial indicator card was exceedingly high as compared with the apparent effort required. The reason is that the plan in taking the cards was to make the first one at the instant of closing the circuit, thus giving a card due to the simple dead resistance of the motor which, with a ratio of peripheral velocities necessary for this work and a speed of 30 miles per hour, would necessarily be low, and occupy at least a few seconds in developing an economic working resistance.

The indicator cards became a minimum at the maximum velocity of the train, but quickly arose where the gradient is 98.7 feet per mile. The effect, however, of acquired momentum was very evident, since neither the indicator cards nor the declining velocity were at all proportional to the resistance imposed by the gradient, and the speed of the train varied but little from this point to 46th street, being only slightly increased on the down grade between 34th and 42d streets.

The run of 1.846 miles was made in 4 minutes and 51½ seconds, as recorded by the chronograph. This is at the mean speed of 22.84 per hour, with a maximum of 28.4 miles per hour indicated on the up-grade between 44th and 46th streets. The speed in passing 23d street, the end of the level stretch, was 28 miles per hour.

The mean power exerted at the central station for propulsion during this trip was 103 h. p., which will compare not unfavorably with steam practice.

With a four-car express train, having a total weight of 70 tons, or about the average weight of a four-car loaded Ninth avenue train, the characteristics of the two-car run were very nearly reproduced, though it was particularly noticeable that the indicator line did not show so large an increase as one might expect from doubling a number of cars; but this is accounted for by the greater ratio which the friction and load of the motor presented to the two-car train. The total time of the trip with this train, consisting of four Sixth avenue cars, each weighing 15 tons, plus the motor weighing 10 tons, was six minutes and six seconds,

with a mean speed of 18.15 miles per hour, and with a maximum speed of 25.24 miles per hour between 42d and 43d streets. The mean power exerted at the central station on this run was 129.3 h. p. This result is almost exactly the same as the running time of the express steam trains of equal weights over the same distance.

Several four-car "stop runs" were made, chiefly for the purpose of demonstrating the ability of so light a motor to stop at the foot of a gradient of 98.7 feet per mile—as at 30th street—with a train of 70 tons, and ascend the gradient from a position of absolute rest with ease. These "stop runs" were made many times without encountering any difficulty whatever, and at no time during the whole tests has the motor shown indications of over load. The four-car "stop runs" were not made in schedule time, owing to the exceedingly prejudicial effect of the absence of an efficient brake system, compelling the opening of the circuit two or three blocks before the station was reached in order to insure a proper stop at the platform. This considerably lowered the speed, and of course stopped the rapid acceleration of other runs.

That there is not a marked difference between the 10-ton motor and the 18-ton locomotive in the initial effort on the level may be seen by comparing a run observed by a Manhattan railroad official, on March 9th last, with a steam motor and three-car train with 75 passengers, or a total of about 57½ tons. While the steam motor required one minute and thirty-nine seconds to make the distance from 14th to 23d streets, the electric motor in the four-car run accomplished the trip, with a train weighing 14 tons more, in 1 minute and 50 seconds, or only 11 seconds added for the increased 14 tons. Not a discouraging exhibit for the electric motor.

While the mean speed in the "stop runs" was not equal to the ordinary schedule of the Ninth avenue road, it is nearly equal to that of the Third avenue with 22-ton motors and 80-ton trains. In considering the apparent mean expenditure of power at the central station, it should be borne in mind that the effort exerted by these motors on such rapidly varying gradients and over such short distances on the elevated railroads are not by any means represented by the ordinary co-efficients of train resistance and effect of gravity, as it has been before pointed out very clearly by others that, while the up-grades always exert their full effect, the advantage generally obtained from down-grades on long runs by acquired momentum is here nearly always lost by the position of the gradients with reference to the stops. It has been shown by Messrs. Sinclair and Campbell that on the Third avenue road, with the 80-ton trains and 22-ton motors, 170 h. p. is not infrequently exerted; hence to consider this problem merely by the ordinary co-efficients of rolling friction and gravity resistance, would, and does frequently, lead to serious errors in computing the amount of power actually used on short railroads with frequent stops.

For many years, said Mr. Daft, the electric motor struggled hard to prove its ability to compete with even the most costly competitors, namely, manual labor, and even here the introduction of the dynamo machine was necessary to achieve the victory; then quickly followed the long competitive battle with horses, in which it is evident the equine has been signally defeated. But to wrest a victory from the steam locomotive in its own domain is quite another matter; but he thought his hearers would agree with him that a large economy in the vital item of fuel, under decidedly adverse circumstances, may be asserted without dangerous optimism, and the result of all these tests has seemed to prove that the measurements might be laid bare without in the least shaking the confidence of competent judges in the ability of the electric motor to replace steam for service, at least as severe as that of the elevated railroad systems.

Mr. Daft here submitted the following tables :—

No. 1.

10 *three-car trains to be run under six minutes headway between 59th street and South Ferry.*

Train No.	Location.	H. P. required.
10	Starting at 59th street.	200
9	Up grade to 34th street.	150
8	Running on level.	130
7	" "	130
6	Starting at Battery place.	190
5	" " Rector street.	190
4	Running on level.	130
3	" "	130
2	Down grade to 42d street.	...
1	On switch at 59th street.	...
		1,250
	Add 10 per cent. for contingencies...	125
	Total	1,375 h. p.

No. 2.

Estimated amount of power required to equip, electrically, the 9th avenue division of the Manhattan Elevated Railway.

10 *four-car trains to be run under six minutes headway between 59th street and South Ferry.*

Train No.	Location.	H. P. required.
10	Starting at 59th street.	200
9	Up 52 feet grade to 34th street.	200
8	Running on level.	150
7	" "	150
6	Starting at Battery place.	200
5	" " Rector street.	200
4	Running on level.	150
3	" "	150
2	Down grade (52 feet) to 42d street.	. .
1	" " into switch 59th street.	...
	Total	1,400
	Add 10 per cent. for contingencies	140
	Total	1,540 h. p.

No. 3.

15 *four-car trains to be run under four minutes headway between 59th street and South Ferry.*

Location of trains when train No. 15 has been run under way two minutes. This gives larger results than when train No. 15 is starting from 59th street.

Train No.	Location.	H. P. required.
15	Down 105 feet grade to 50th street.	...
14	Up 52 feet grade to 34th street.	200
13	Running on level.	150
12	Starting at Christopher street.	200
11	Running on level.	150
10	Starting at Cortlandt street.	200
9	" " South Ferry.	200
8	" " Battery place.	200
7	" " Barclay street.	200
6	Running on level.	150
5	" "	150
4	Up grade from 23d street to 30th street.	200
3	Down grade to 42d street.	...
2	Up 105 feet grade to 59th street.	250
1	On switch.	...
		2,250
	Add 10 per cent. for contingencies	225
	Total	2,475 h. p.

No. 4.

20 *four-car trains to be run under three minutes headway between 59th street and South Ferry.*

Advancing trains 1 minute from start.

Train No.	Location.	H. P. required.
20	Down grade to 50th street.	...
19	" " to 42d street.	...
18	" " to 30th street.	...
17	Running on level.	150
16	" "	150
15	" "	150
14	Starting at Franklin street.	200
13	" at Barclay street.	200
12	" at Battery place.	200
11	Running on level.	150
10	Starting at Rector street.	200
9	Running on level.	150
8	Starting at Warren street.	200
7	Running on level.	150
6	" "	150
5	" "	150
4	Starting at 30th street.	220
3	" at 42d street.	200
2	Up grade to 59th street.	250
1	On switch at 59th street.	...
		2,870
	Add 10 per cent. for contingencies	287
	Total	3,157 h. p.

RESUME.

And to obtain the average for the day.

Train No.	Cars on Train.	Headway.	Time. A. M. A. M.	Time in Service hrs.	min.	H. P.	H. P. hours.
10	4	6 min.	5.09 to 6.03	0	54	1,540	800
20	4	4 "	6.03 to 6.15	0	12	3,157	631
21	4	3 "	6.15 to 7.00	0	45	3,157	2,367
20	4	4 "	7.00 to 7.24	0	24	3,157	1,315
21	4	3 "	7.24 to 7.41	0	17	3,157	1,052
20	4	4 "	7.41 to 9.03	1	22	3,157	4,209
10	3	6 "	9.03 to 4.15 P. M.	7	12	1,375	9,900
20	4	4 "	P. M. 4.15 to 5.07	0	52	3,157	2,735
22	4	3 "	5.07 to 5.53	0	46	3,157	2,420
20	4	4 "	5.53 to 6.18	0	20	3,157	631
10	4	6 "	6.18 to 9.00	2	47	1,540	2,880
				15 hrs.	51 min.		29,940

Average horse-power per hour $\frac{29,940}{16} = 1,871$ h. p.

To which must be added the power consumed in engine and dynamo friction and loss in line.

$$\begin{array}{rr} & 1,871 \\ \text{Station friction} & 300 \\ \hline & 2,171 \text{ h. p.} \end{array}$$

Evaporation 7.5 water for 1 lb. coal.

Hence coal consumption,

2,171 x 16 x 2.2 = 38 + 3 tons for banking = 41 tons.

at $2.25 = $92.25 per day.

From this table, it will be seen that for five hours out of the 16 of daily service, 2,870 h. p. would be required, or adding 10 per cent. for contingencies, 3,157 h. p. during these times when 20 and 21 four-car trains would be in operation under three minutes headway, being reduced to 1,250 h. p., or adding 10 per cent. for contingencies, 1,375 h. p. for the 7 hours and 12 minutes inter-

vening between 9.03 A. M. and 4.15 P. M., when 10 trains of three cars are in service under six minutes headway, while during 54 minutes of the early morning between 5.09 A. M. and 6.03 A. M. and the late evening service of 2 hours and 47 minutes between 6.13 P. M. and 9 P. M., in which case 10 four-car trains are in service, 1,400 h. p. would be required, or, again adding 10 per cent., 1,540 h. p.

It should be remarked that the power indicated for this service might be very advantageously divided up into four engines of 800 h. p. each, as an examination of the traffic table will show that for only five hours per diem the whole of them would be required, and during the long period of 7 hours and 12 minutes between 9.03 A. M. and 4.15 P. M., two of the engines would be ample for the service.

The results, however, show that the total horse-power per diem equals 29,940, or, divided by 16 (the number of hours of service) 1,871 h. p. per hour, and adding 300 h. p. for dynamo and engine friction the total should be 2,171 h. p. per hour, which at 2.2 lbs. of coal per horse-power per hour equals 38 tons of fuel consumed per diem, and adding three tons, for banking the fires equals 41 tons at $2.25 per net ton, or a total of $92.25 per diem for fuel alone.

In this connection said Mr. Daft, the coal referred to is a mixture which may be obtained at the dock in New York, for about $1.80 per ton, and which is shown by Barrus in his work entitled "Boiler Tests," to be capable of evaporating 7½ lbs. of water per pound in a properly constructed furnace.

There are several makers of compound engines in this country who will guarantee the performance of their engines on 16 lbs. of steam per horse-power per hour. It is thus evident that the amount of coal above referred to, is a safe one for modern practice on so large a scale. The present locomotives on the Ninth avenue, require an average of 40 tons of coal per day for motive power and breaking, but experience has shown that it is economical in small locomotive practice, to use coal of the best quality, hence the cost of this 40 tons of coal is $200 per day, or more than double the cost of that for the electric motive system.

It is of course, necessary to add to the electric estimate a number of charges, such as wages of firemen and engineers at the central station, which would probably bring this item up to about $150 per diem, considering other items balanced by their practical equivalent in the present service and the cost of repairs, depreciation, etc., to be about equal, which is not far from the fact. It is thus evident that without considering the future obvious advantages which must necessarily accrue from the use of a great central station equipped with dynamos as before stated, and a conductive system ample for all requirements of the road, that with the comparatively wasteful central station arrangement we have here considered involving the use of small dynamos of a very old type placed at the extreme end of the conductive system, and suffering from many incidental disadvantages, that it is possible to run the Ninth avenue elevated road with electric motors at an actual and considerable saving of fuel to-day, and if this is not the only example of such a practical demonstration, as opposed to direct steam propulsion, it is at least the first I have been able to find on record.

From the experience derived from these extended tests and from many observations which have been made during the past eight months, Mr. Daft said he had succeeded in eliminating many objectionable features which only such tests could develop, and had devised another motor, now nearly complete, capable not only of doing such work as is at present accomplished, but of solving, at least for the near future, the vexed problem of extended traffic for the elevated railroads; a motor which he confidently expected to be capable of towing at least a six-car train on the Ninth avenue elevated road with a considerably increased average speed and with a comparatively low initial effort.

In his new plans the braking of the motor and train had been electrically provided for, also, of course, the lighting of the cars; but as this machine had not been actually finished, he would not further refer to it other than to call attention to a part of the general plan, namely, the conductor, a section of which has already been placed on the Ninth avenue elevated road at the curve below 14th street.

That the plan first suggested by the late Sir William Siemens of braking the train by converting the motor into a dynamo and so returning a part of the stored up energy of the train to the conductive system would result in considerable economy, there could be no doubt, Mr. Daft thought, provided a thoroughly satisfactory method of practical application were forthcoming; but it is an item that does not appear very conspicuously in any of the quantitative examinations yet seen by him of any electric system, and while he did not wish to be understood as lightly estimating such an obvious economy before accepting it as an important factor, he would like to see a few carefully digested observations of actual performance with motors of high power.

In conclusion, Mr. Daft trusted that if the foregoing facts were not accepted as conclusive proof that the problem of rapid transit was already solved, they might at least furnish a sufficient amount of tangible data to assist in an early and complete accomplishment of our most sanguine hopes.

ALTERNATE CURRENT WORKING.[1]

BY W. M. MORDEY.

(Continued from page 321.)

Now I will briefly describe some experiments with two of my alternators, each made for 2,000 volts and capable of working continuously at 35,000 to 40,000 watts, or, say, 50 E. H. P. output.

Arrangement.—Each machine was driven by a 75 I. H. P. Fowler engine. These engines were similar, their normal speed of working being 120 revolutions per minute. Each of the engines, which were not coupled or connected in any way, was provided with a heavy fly-wheel, and drove, besides an alternator, a heavy and wasteful double (and in one case treble) set of countershafts provided with a large number of belts, fitted to an arrangement of fast-and-loose pulleys for convenience of testing all sorts and conditions of dynamos. I mention this as showing that the momentum in each case was very considerable.

In order to make the test as onerous as possible, the pulleys used were such that one engine had to run at 130 revolutions, while the other ran at 90 revolutions, when the alternators were at their normal speed of 650 revolutions per minute.

(1) The alternators were run up to full speed, and each excited to give 2,000 volts. When in phase they were switched parallel without any external load, and without any impedance coils or resistance between them.

They ran parallel perfectly.

(2) A considerable inductionless load was then put on, varied, and taken off. They ran equally well under all circumstances.

(3) They were uncoupled, and then, the load being connected to the mains, they were suddenly and simultaneously switched parallel and on to the mains with perfect success.

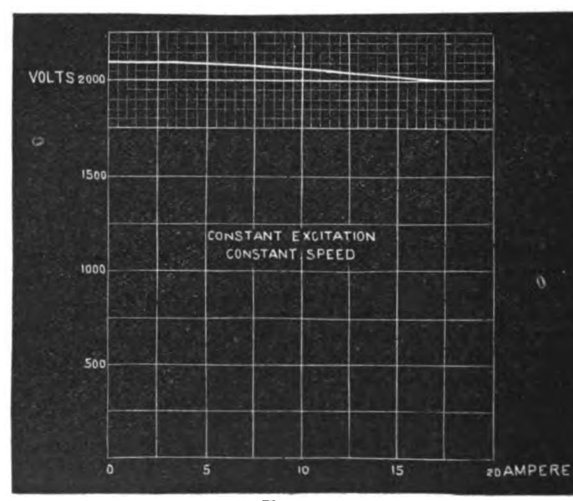


FIG. 1.

(4) One alternator was excited to give 1,000 volts, the other giving 2,000 volts. They were then switched parallel, and went into step perfectly, giving a terminal P. D. of about 1,500 volts. No impedance or resistance was used in this or in any other case. A load was then put on without affecting their behavior.

(5) With one machine at 1,000 volts and the other at 2,000 volts they were switched parallel *when out of phase*, and instantly went into step. A large current appeared to pass between them for a fraction of a second, but not nearly long enough to enable it to be measured, or to do any harm.

(6) They were then left running parallel while one was disconnected from the engine, by its belt being shifted from the fast to the loose pulley. It continued to run as a motor synchronously. A load of lamps was at the same time on the circuit.

(7) The two machines were then uncoupled and excited up to 2,000 volts. They were then switched parallel when out of phase and without any external load, and went into step instantly.

(8) Whilst running as in (7), steam was suddenly and entirely shut off one engine. The alternators kept in step perfectly, one acting as a motor and driving the large engine and all the heavy countershafting and belts. It was impossible to tell, except by the top of the belt becoming tight instead of the bottom, which machine was the motor.

To find the power exerted by the alternator acting as a motor (in 8), a direct current motor was put in its place, and the power required to drive the engine and shafting was found to be 20 h. p.

It may be pointed out that these tests were made under the most exacting and onerous conditions that could possibly be imposed, and particularly I would point out that on account of the very great momentum of the revolving masses, nothing but the strongest and most instantaneous motor action could have

1. A paper read before the Institution of Electrical Engineers, London May 23d, 1889.

kept the machines in phase. There never was a single case when they got out of step, even momentarily, or when subjected to sudden and violent variations of load. When it is considered that, in order to secure this result, it was imperative that the control of all that mass should be exerted in a fraction of $\frac{1}{100}$ of a second (the periodicity being 100), it will be recognized that there was no time to be lost, and that the use of any self-induction or resistance, or of anything else that could in any way choke, retard, check, or interfere with the strength and instantaneity of the action was above all things to be avoided.

I should mention that the machines apparently synchronized equally well at speeds varying very considerably.

As to the self-induction of the machine itself, that is quite negligible. Its characteristic (figure 1) is nearly straight, about half the drop in the curve being due to resistance and half to self-induction.

Here was a machine generally allowed to be good when working singly, but possessing all the qualities that have been stated as unfitting it for parallel work, tested under all the conditions that are recognized as most trying, even for those types of alternators which are universally, and, I believe, erroneously, regarded as best suited for parallel work, and behaving throughout in a manner that simply left nothing to be desired, and carrying, unimpaired, into parallel work those features which it possesses when run singly.

I trust that I have now said enough to justify the views I have expressed.

A few particulars of this machine may be of interest. It now takes 500 watts to excite it at full load, and rather less than 400 watts on open circuit with full E. M. F. The efficiency when working with a light load is very high. The power required to run at full speed, with full E. M. F., but no external load, is 3 h. p., of which 1.5 h. p. is ordinary mechanical loss in the bearings, &c., and 1.5 h. p. is electrical waste in the armature conductors and supports. This is from a most careful test, and shows that, so far as economy is concerned, with light loads the machine does not leave much to be desired. This is really of very great importance, for the expense connected with central station working during the long hours of daylight may be a serious item.

ALTERNATE CURRENT MOTORS.

The bearing of the foregoing on the great and vital question of the construction of alternate current motors is obvious. Much work has been done of late on this subject, and no doubt considerable success has been met with, but the use of alternators as simple synchronizing motors has not appeared to attract much attention, probably because it is not known what excellent results may be obtained in this direction, and partly because of their inability to start from rest.

The experiments just described, and others that I have carried out, showed what perfect self-governors such motors are. Not only do they maintain synchronism, but they possess an inherent economy which is most valuable. Just enough current passes through them to keep them in step, and to do the work imposed on them. They become generators, and do work on the circuit, if from any cause there is a tendency for them to run faster than the generator.

I have devised a very simple means of starting such motors, which at a small expense removes the only drawback to their employment. The exciter, which is geared directly in some way with the alternator, is used, in conjunction with a small accumulator, as a direct-current motor to start the alternator. When synchronism is attained the latter is simply switched into circuit. It will be obvious that a small battery capable of a heavy discharge for a minute or two is all that is required. This is recharged by the exciter. I need not go into the details of the arrangements. This is perfectly practical. I should have no hesitation in running these alternators in regular work as motors, and should expect to find their "commercial efficiency" very nearly or quite 90 per cent.—about the same efficiency, whatever it is, that they possess as generators. For instance, the machines alluded to will work as motors at a useful output of 50 h. p., with this efficiency.

And here is another advantage in getting alternators economical when on open circuit. By doing so it becomes possible to use the very small exciter as a direct-current motor to get them up to the synchronizing speed.

In many situations a synchronizing A. C. motor will fulfill all requirements, and will do so with fewer drawbacks than any other kind of electric motor whatever. It will be a better regulator, more economical, less troublesome to look after, much safer to handle, and (what is of very great importance in connection with the transmission of large powers to a distance) the difficulty of dealing with high pressures, which is so serious with direct-current motors, is very easily overcome, for not only will alternators stand a higher tension in themselves, but, if necessary, transformers may be used to reduce the pressure between mains and motor.

PERIODICITY.

Some confusion is caused by the various ways in which rates of alternation are expressed, it being often quite uncertain whether periods or half-periods are referred to when "alternations" or "reversals" are spoken of. This confusion should be avoided by using the term "period," which has, I think, always been taken as expressing the complete cycle, or the changes undergone by a simple rectangle or elementary armature rotated from zero through a complete revolution in a simple magnetic field. To save confusion I always write it thus ∿; and I would suggest that this sign be used, unless a better one be forthcoming, and that we agree to speak of periods, instead of alternations or reversals, and of periodicity, instead of frequency or rates of alternation or of reversal.[1] Professor Silvanus Thompson informs me that formerly a somewhat similar difficulty arose in regard to sound, and that confusion was avoided in the science of acoustics by giving the word "vibration" the definite meaning of the double motion which it now possesses, the French tuning-forks being stamped with the letters "V. D." (*vibration double*) after the number.

The subject of periodicity is becoming a very important one, for both commercial and scientific reasons. It urgently demands settlement in the interests of the whole industry. The very wide differences found in scientific opinion on this matter, and in the practice of the various manufacturers, must lead—and are, indeed, now leading—to much confusion and inconvenience. As things stand at present, great uncertainty exists not only as to what rate is the best, but whether transformers, arc lamps, or other apparatus made by one maker, for a given E. M. F. or purpose, can be used on a circuit fed from an alternator constructed by another maker. It might be suggested that some joint action should be taken by manufacturers and others concerned in the direction of securing uniformity; but there are arguments against such a course, the principal one being that probably each maker believes he has good reasons for his own practice.

I venture to think there is no right or wrong periodicity. What may be best for one set of conditions, or with one type of apparatus, may not be best for another. Or, perhaps it would be more correct to say that there is a right periodicity, and that there are right and wrong apparatus; but this is rather a delicate subject.

The relative advantages of high or low periodicity must be considered as bearing on the five main divisions of apparatus used. Taking these in their natural order, they are—"1, Prime motors; 2, Alternators; 3, Conductors; 4, Transformers; 5, Lamps, &c."

Each of these divisions contains matter in relation to periodicity which in the near future will probably form the subject of many papers, as the various subjects become better understood. I am not able to do more than touch briefly on each, in the hope that my remarks may lead to the expression of the views of others, and to some approach to uniformity.

1. *Prime motors.*—At present questions affecting prime motors do not usually bear directly on the subject of periodicity. The only exception is the Parsons steam turbine, with which there seems to be no great difficulty in using a simple two-pole machine, thus making the number of revolutions and of periods the same. There may be found some want of flexibility as regards changes of size or output with such turbines, as, from the nature of the case, speed can only be varied by very large amounts. Thus, for instance, if 100 ∿ are required, there is no choice except between a two-pole machine at 6,000 revolutions per minute and a four-pole machine at 3,000 revolutions. This is, of course, on the assumption that the alternator is driven direct. If indirect driving is resorted to the difficulty is much reduced. It is unlikely, however, that the bearings of a steam turbine would work satisfactorily except with direct driving.

2. *Alternators.*—It is not allowable to doubt that the divergencies in periodicity found in practice are to a great extent the result of development and survival of what has been found to give the best results in each case; but from an examination of the machines in use it is very difficult to trace any common line on which action may be supposed to have taken place. It is true that the general tendency has been towards a reduction of the periodicity, but the causes which are responsible for that tendency are very obscure. I have seen large and small machines, made at the same time by one maker, in which the number of coils was the same, although one had to run at about 2,000 revolutions per minute and the other at less than half that rate of speed. At least one of these was wrong. For the purpose for which these machines were made, the very high periodicity was almost unobjectionable in the small machine, but in the large ones it led to disaster.

It is a common mistake to suppose that high speed of driving, or high peripheral velocity, are necessarily connected with high periodicity and with large output. Of course any given machine, if run at a higher rate of speed than its normal one, must have a proportionately higher periodicity, but will not necessarily be capable of a greater output. It is quite possible to design a high-speed machine to give a low periodicity, and *vice versa*. Perhaps the impression has arisen because with most alternators it is not

1. This sign may be written something like, but rather larger than the algebraic sign (∽) for "difference."

possible or desirable to place the successive poles very close together on account of the magnetic leakage.

For machines with iron in the armatures it might be expected that the magnetic and electric losses, as well as the very considerable self-induction and consequent variations in the effective potential difference with changes of load, would lead to the reduction of the periodicity; but experience does not seem to have always led to this result. The lowest periodicity (42 with the Zipernowski machine) and the highest (133 with the Westinghouse machine) are both found in alternators having iron cores. What is the reason of this great diversity? The machines have many points of resemblance, and yet one is run at more than three times the periodicity of the other. Not having seen the American machine, I can offer no opinion based on personal observation; but of the Austrian alternator I can say that, in my opinion, it would not be advisable to increase the rate.

In a communication from Messrs. Ganz & Co., published a few days ago,[1] Mr. Zipernowski says that the low periodicity used was chosen on principle to enable them to couple their dynamos parallel. He very cogently adds, in justification of this:—"At present no practical electrician will hesitate to acknowledge the coupling of dynamos in parallel circuit to be a vital question of any parallel system of central station distribution."

This bears out very completely my contention that the periodicity is governed in most cases by some special feature of the type of apparatus. Zipernowski has had to go down to 42 ∿ to get his iron-cored alternators to synchronize, and for no other reason; for his statement is that synchronous action was "not a secondary result, but just the end we were aiming at," and he acknowledges that there are disadvantages connected with this low rate in other parts of the system.

same. Regarding this machine, I think I may say that periodicity is not a question of the first importance. As far as I am concerned it is other divisions of the distributing apparatus that determine the rate at which it is desirable to work.

The bearing of the form and arrangement of any alternator on the best periodicity for that alternator is a very close one. The question cannot be settled on general principles.

I have referred elsewhere more fully to the conditions as they affect regulation under varying loads, parallel working, and other points in connection with alternators; and, as an appendix, I have quoted some observations made recently at the Institution of Civil Engineers during the discussion on Mr. Kapp's paper on "Alternate Current Machinery," and not yet published.

I now pass on to the next division of the subject.

3. *Conductors.*—The choice of a suitable periodicity depends also to some extent upon the conditions as they affect the conductors.

The effect of rapid alternations in virtually increasing the resistance of conductors has been brought before us in Sir William Thomson's presidential address, and it becomes necessary to recognize clearly what practical limitations are imposed by this effect.

My attention was drawn to this matter two or three years ago, when I was called upon to examine and report upon an installation of about 1,000 100-volt lamps supplied directly by an alternator working at about 150 ∿. It was found that there was a very serious drop of potential in the conductors, and, in consequence of this, the lamps could not be maintained at full power. On examining the circuit I found the cables were of ample size, and that the loss could not be explained in the usual way. As a result I came to the conclusion that it was to be accounted for only by some kind of inductional action, due to the alternating current, and I advised that a direct-current dynamo should be put down in place of the alternator. This was done, and with a perfectly satisfactory result. The lamps were for the first time run at their proper power, and no further trouble was experienced.

TABLE I.—VIRTUAL RESISTANCE, &C., OF CONDUCTORS WITH ALTERNATE CURRENTS.

Diameter.		Area.		Increase over ordinary resistance.	Current at 450 amperes per square inch.	Watts at 2,000 volts.	Watts at 100 volts.	∿ per second.
MM.	Inch.	Square mm.	Square inch.					
10	.3937	78.54	.122	Less than $\frac{1}{100}$ per cent.	55	110,000	5,500	80
15	.5905	176.7	.274	$2\frac{1}{2}$ "	133	266,000	13,300	
20	.7874	314.16	.487	8 "	220	440,000	22,000	
25	.9842	490.8	.760	$17\frac{1}{2}$ "	......	....	......	
40	1.575	1,256	1.95	68 "	......	....	.....	
100	3.937	7,854	12.17	3.8 times	......	....	......	
1,000	39.37	785,400	1,217	35 times	......	....	......	
9	.3543	63.62	.098	Less than $\frac{1}{100}$ per cent.	45	90,000	4,500	100
13.4	.5280	141.3	.218	$2\frac{1}{2}$ "	98.5	197,000	9,850	
18	.7086	254.4	.394	8 "	178.	356,000	17,800	
22.4	.8826	394	.611	$17\frac{1}{2}$ "	.....	....	......	
7.75	.3018	47.2	.071	Less than $\frac{1}{100}$ per cent.	32	64,000	3,200	133
11.61	.4570	106	.164	$2\frac{1}{2}$ "	74	148,000	7,400	
15.5	.6102	189	.292	8 "	131.4	263,000	13,140	
19.36	.7622	294	.456	$17\frac{1}{2}$ "	......	......	......	

But Westinghouse with 133 ∿ and Lowrie-Parker with 80—both having iron cores—can run parallel, the former with not less than half-load, the latter, as we now know with any load, and I think I could run parallel without iron and at any load and periodicity, so that Mr. Zipernowski's only reason fails to justify his action, except as regards his own particular apparatus.

Professor Forbes recently stated that the exhaustive tests made in America with the Westinghouse apparatus had shown that there was no reason for reducing the rate of alternation, which is the highest now in use. This is very important, and it is to be hoped that some account will be given of the nature of the trials and of the results obtained. Mr. Ferranti, who at one time used very high rates, has for some time been using 80 ∿ at the Grosvenor Gallery, and has fixed 68 ∿ for the Deptford machines. I shall not be surprised to see him increase this before long.

In my own machine the periodicity is 100, which, I believe, is on the whole the best rate; but if it be required to do so for any special purpose, there would not be much difficulty in changing it. The pole faces can be altered in number and in size by merely altering the pattern; the field winding, being in a single coil, would be equally simple and equally efficient for any periodicity. Even with a large number of poles placed close together, as would be required for a high rate, magnetic leakage would not increase. The size of the machine would not be sensibly affected. The armature would certainly be rather more costly for a high rate, as a greater number of coils would be required; but the efficiency, output, and regulating qualities would remain practically the

At that time I was, like most other electricians, a disbeliever in alternating currents, which I vaguely regarded as essentially unsatisfactory. I think there was a more substantial basis for this opinion than is now generally admitted. Alternating currents as then most often used were not satisfactory; and if great care is not taken at the present time, some of the old difficulties will be encountered, with the result of unnecessarily discrediting the transformer system of distribution.

From Sir William Thomson's address, and from some further information he has kindly sent me, I have worked out and tabulated some figures showing what restrictions are imposed by the virtual increase of resistance of solid conductors with alternating currents, as bearing on the question of periodicity.

Sir William Thomson gives some figures for a periodicity of 80, to which I have added some columns giving diameter in inches, sectional area, and the current which the practicable sizes will carry, taken on the basis of 450 amperes to the square inch, because that density gives 1 *per cent. loss per mile* with 2,000 volts. It also gives about 1 *per cent. loss per* 100 *yards* with 100 volts, or, more exactly, 1.15 per cent. I have also given the number of watts at 2,000 volts, and at 100 volts, for each size, to show the limits for ordinary primary and secondary working with this density. These figures are given for 80, for 100, and for 133

1. The *Electrician*, May 10th, 1889, p. 16.

∿, the diameters of conductors for the same percentage increase of virtual resistance over ohmic resistance being in the inverse ratio of the square roots of the periodicities.

It will be seen that for 100 ∿, with wires of 9 millimeters, or .35 inch diameter, the increase over the ordinary resistance is almost imperceptible; for a diameter of 13.4 millimeters, or .53 inch, it is only 2½ per cent.; while what may be considered a practical limit is reached at 18 millimeters, or nearly ¾ inch. At greater diameters the increase is prohibitive, and multiple conductors, tubes, or strips must be used. Probably an increase of 8 or 10 per cent. will be considered quite permissible. It sounds a good deal, but it must be remembered that it is only 8 or 10 per cent. of the 1 or 2 per cent. loss for which primary conductors are usually calculated.

Looking at the limitations as regards output, it may be said that for primary distribution, even at no higher tension than 2,000 volts, the virtual resistance effect is, if not quite unimportant, at any rate not very serious. A current of about 200 amperes may be conveyed without the effect showing itself to any very objectionable extent. There may be differences of opinion on the subject, but most people will agree that 300,000 or 400,000 watts is quite as much as should be supplied through any single conductor. In most cases, even at ordinary tensions, subdivision of the primary will be necessary or advisable before such a power is reached. With still higher pressure, of course, enormous powers can be dealt with without exceeding the permissible size of solid conductors. It is to be observed that there is nothing, in this virtual resistance effect, to necessitate the reduction of current by the employment of very high pressures.

It is only with the low tension secondary conductors that this effect becomes in any way serious. With 100 volts the maximum load at this density that can be put on a single solid or stranded conductor is about 13,000 watts for 133 ∿, 18,000 for 100 ∿ and 22,000 watts for 80 ∿, unless much more than the 8 to 10 per cent. increase can be endured. This only means in large distribution work a subdivision of the primary and secondary feeding points in accordance with this limitation. The inconvenience has only to be recognized to be avoided. Fortunately it is not one that with ordinary care is likely to lead to any practical inconvenience. It exists with alternate currents, but it is a matter that the transformer system renders it very easy to avoid. Transformers lend themselves to subdivision of work, and with subdivision this difficulty does not exist.

It may be worth noting, in connection with this part of the subject, that the improvement in alternators, and the great ease with which they and their circuits can be worked and controlled, may lead to some revival of the practice of supplying direct from low-tension alternators. If this is done for any but very small installations, it is evident that special precautions must be observed to avoid the difficulties which have been referred to.

One other remark on this subject. Very large conductors are to be avoided in the transformers as well as outside of them. This is only mentioned on account of its bearing on transformers for any very low tension work, such as electric jointing or welding, where one or two turns of secondary conductor is often sufficient.[1]

4. *Transformers.*—There appears to be a general belief that a high periodicity is best for transformers, and that this gives the greatest output, or—what amounts to the same thing—that with the same output in the two cases a higher efficiency is obtained when the periodicity is high than when it is low. This supposed fact has often been stated.

Professor Forbes—who has, I believe, given much attention to the theory of this very difficult subject—contributed a paper last year,[2] consisting of a mathematical examination, which is summarized and concluded by a statement that the periodicity may be diminished without loss of efficiency if the iron be increased; the corollaries being, of course, that the periodicity may be increased without loss of efficiency if the iron be reduced, and that with any given transformer an increased periodicity results in increased efficiency for the same output, or in greater output with the same efficiency.

Professor Forbes confirmed this view recently, in the discussion on a paper by Mr. Knapp before the Institution of Civil Engineers, by pointing out that one of the reasons why in America they used a high periodicity was that "they wanted to get the greatest output from their plant, and transformers had to be increased in size in order to give the same output if they lowered the number of alternations."[3] And, in his recent paper on "Central Stations" before this Institution,[4] Professor Forbes reiterated this. He states that the contrary is "opposed alike to experience and theory. Westinghouse knows this. I am informed Mr. Ferranti knows it, and Mr. Zipernowski has told me that he finds it so."

Mr. Kapp, who works at 80 ∿, does not go so far as Professor Forbes, for he thinks that on account of viscous hysteresis there must be a limit beyond which an increase becomes disadvantageous. He wisely adds that it is not possible to determine this limit on theoretical grounds.

On the other hand, it has been said that it is not necessary to increase the size of transformers even for very low periodicities, because, when the number of cycles is small, it is possible to work at a higher magnetic density.

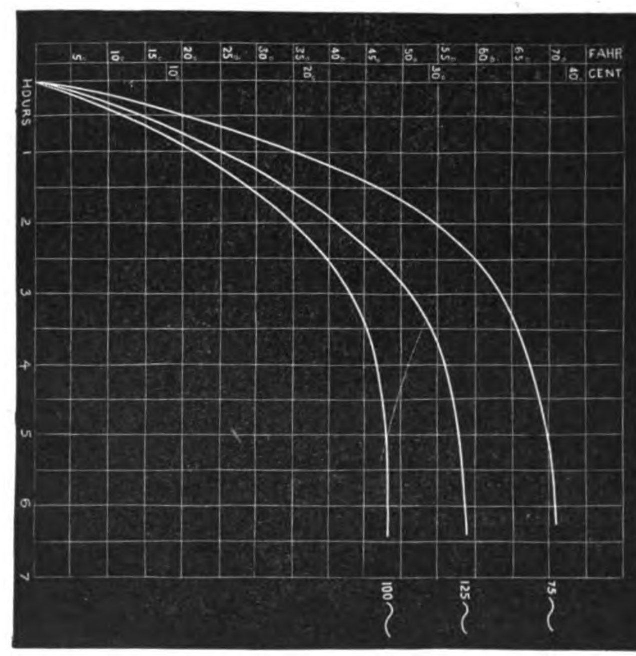


FIG. 2.

I venture to question the accuracy of both these extreme views.

So far as transformers are concerned, and speaking only from experience, I think that high and low periodicities are both wrong, and that a medium rate is right. For a given output and efficiency, not only must transformers be made large for low rates—they must also be made large for high rates; but between the two there will be found a periodicity giving the smallest size of transformer, or the greatest output, or the highest efficiency.

Figure 2 illustrates this. It shows the rise of temperature of one of my transformers working respectively at 75, at 100, and at 125 ∿ per second. The primary and secondary virtual potential differences were measurably the same in all three cases, and in each case the same load was used, consisting of a certain number of glow lamps. The test was continued each time long enough for the transformer to attain its maximum temperature. This was taken by a sensitive thermometer, the bulb of which was placed directly on the iron, and covered by a packing of cotton waste to ensure that, as far as possible, at least the actual temperature of the iron should be indicated. Another similar thermometer was placed a few feet away to show the temperature of the room (which was fairly constant at about 60° Fah.).

The curves give the actual increments of temperature, which may be taken as some sort of measure of the relative efficiency attained. With any given output the same rise of temperature is, of course, always obtained with the same efficiency, quite apart from how that efficiency is made up. It will be observed that the lowest temperature or the highest efficiency is obtained at 100

1. The following particulars refer to conductors for primary circuits working at 2,000 volts, and show the sizes for various numbers of lamps giving a loss of 1 per cent. per mile run.
Data for copper conductors working with 2,000 volts pressure at the primary terminals of the transformers.
Transformers taken at 95 per cent. efficiency.
To allow 1 per cent. loss of pressure per mile of conductor, the primary current-density should be 450 amperes per square inch.

Conductor for any given number of 60-watt lamps.

Sectional area, in square inches = number of lamps × .00007
Weight per mile, in lbs. = " " × 1.44
Resistance per mile, in ohms = 680 ÷ number of lamps.
The following conductors comply with the above rule, and none of them is affected by the virtual resistance effect :—

TABLE II.

Number of lamps.	B. W. G. No.	Diameter.	Sectional area.	Weight per mile.	Resistance per mile.
		Inch.	Sq. inch.	Lbs.	Ohms.
100	13	.096	.007068	144	6.3658
200	10	.134	.014102	286	3.1890
300	8	.165	.02138	433	2.1102
400	6½	.191	.02865	578	1.5747
1,000	1	.300	.07065	1,433	0.6401

2. "Formulæ for Converters," *Journal*, vol. xvii., p. 153. This paper was no doubt intended only as a mathematical investigation. It contains several assumptions that Professor Forbes would probably not rely upon in practice.

3. Proc. Inst. C.E. February 19th, 1889.
4. *Journal*, xviii., p. 194 (February 28th, 1889).

$\sim$; that the efficiency is lower at 125, and lowest at 75 $\sim$.

On these lines I may suggest a method of arriving at the efficiency of transformers, which, though lacking in directness, is simple, and requires only ordinary appliances and facilities.

First run the transformer for some time in the usual way, on incandescence lamps, the output being measured. It is not necessary to make any measurements of the primary. By means of a thermometer find the rise of temperature of the transformer. Then, when the transformer has cooled down, send a continuous current through it and measure the power in watts that raises the temperature of the whole transformer the same amount as when working with alternate currents. This takes some time to carry out, but it is accurate, and has the advantage that the lost power is measured in direct current quantities, about which there is no question; while the power expended in the lamps, being in an inductionless circuit, is easily arrived at correctly. A watt-meter is the best instrument to use for the direct current readings, as, on account of the rise of resistance of the conductor (which is necessarily required to carry much more than the usual current), some adjustment is necessary in order to keep the power constant, and this adjustment is effected much more conveniently with a wattmeter in circuit than if an ammeter and a voltmeter are used.

5. *Lamps, &c.*—Under this head all apparatus for utilizing or measuring alternate currents should be considered, so far as the action is affected by the periodicity. I must, however, confine myself to the lamps, which are the most important, and are the only apparatus as to which I can make any definite statements.

The paper of Professors Ayrton and Perry read last year before the Physical Society[1] showed that the efficiency of glow lamps is the same for both direct and alternating currents. The authors of that paper did not directly allude to the question of relative efficiency with different periodicities, but they evidently had this point in their minds, as the periodicities used in the experiments appear to have been varied from 83 to 226 without showing any difference in efficiency. It may be taken, therefore, that no difference exists. Probably for very low periodicities this would not hold good, but for ordinary rates the question may be considered settled. At very low rates the temperature of the filament would follow to some extent the changes of the current, and would be affected both in life and in efficiency. I suppose that at ordinary rates there is no variation of temperature, the filament acting as a kind of thermal fly-wheel, maintaining its condition unchanged throughout the whole period. We all know, for instance, that, especially with low-resistance lamps, when the current is interrupted, the time occupied in cooling down to blackness is quite appreciable. The periodicity at which the temperature begins to follow the variations of current is a point of some interest, and it is one that can be very easily investigated.

There is, as far as I am aware, no available evidence regarding the life of lamps with different rates, or even as to the relative life with direct and alternate currents. At one time it was considered that alternate currents would give better results than direct currents, because with the latter there was supposed to be some transference of the material of the filament in the direction of the current. Nothing has transpired to confirm or to disprove this supposition, and, as the number of lamps now in use on each system is enormous, the very absence of evidence may be taken as affording a strong presumption in favor of the belief that the life of lamps is independent of whether the current is direct or alternating, and independent also of the periodicity, within practical limits.

Alternate current arc lamps are not seriously affected by variations of periodicity within a fairly wide range. The feeding current of a parallel Brush alternate current lamp remains sensibly constant between 75 and 125 $\sim$, but with the lower rate a slightly higher impedance or resistance is required to secure steadiness of the light.

(*To be continued.*)

THE ELECTRICAL INQUIRY.

[ELECTRICAL EXECUTIONS.]

THUS far the taking of testimony relative to the operations of electricity, in connection with the effort to prolong the life of the murderer Kemmler, has not produced much heat. It must be acknowledged also that it has not produced so much light as might have been expected, though it has been useful in diffusing that which existed before. In view of the fact that the inquiry directly involves the fate of a human being, and, incidentally, the interests of large corporations, or *vice versa*, it is somewhat remarkable that so much good nature and so laudable a desire to increase the sum of human knowledge have been displayed. Some of our contemporaries have contrived to get more or less excited about the matter, but really nothing has occurred before the referee to provoke wrath, either celestial or terrestrial. The testimony has served to disclose to public view an irreconcilable conflict of opinion among experts as to the certainty with which the effect of a given measure of electrical energy upon a human subject can be predicted. The investigation bids fair to leave the experts just where it found them, but it can hardly fail to increase whatever doubt laymen may have felt before as to the superiority of the new law of executions to the old law.

Popular distrust of electricity as a means of inflicting the death penalty has nothing to do with this specific case. When the testimony is all in the referee will make up his report and submit it to the court, and eventually the Court of Appeals, or possibly the Supreme Court of the United States, will declare the law constitutional or otherwise. It is entirely proper that this test should be made, and we have never seen any occasion for sneering at the proceedings now going forward. Whatever interest the people take in them is not inspired by maudlin sympathy with a condemned murderer. The law was not primarily designed to make capital punishment less painful and ignominious, but to make it sudden, certain and decent in respect to its accessories and circumstances. The welfare of the convict was not the first consideration, but the best interests of the community. Kemmler's counsel are endeavoring to show that execution by electricity would be "cruel and unusual," because that is their only means of proving the law unconstitutional; but the public is chiefly concerned in ascertaining whether or not the law certainly provides a decent and efficient method of inflicting the death penalty. It would not be surprising if the people should determine to repeal it, in case it should be held valid by the courts, even if the result of the first experiment on Kemmler should prove successful.

It seems to be taken for granted by most of those who have commented upon the case, that Kemmler could not be executed in any manner if the new law should be declared unconstitutional, and that is, of course, the position which his lawyers will take. There is no necessity for conceding this point—for the courts would certainly be called on to decide whether or not the clause repealing the old law does not stand or fall with the body of the new law—but that consideration is no argument against the present inquiry. It was inevitable that a complete departure from all experience and tradition in the means of inflicting capital punishment should be followed by a strenuous effort to overthrow the legislation which brought it about. Such an effort is now being made. It involves questions of great general interest and importance, and it is quite worth while to learn as much as possible from it instead of treating it with contempt.—*N. Y. Tribune.*

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Passive Condition of the Board of Electrical Control; Reports for Year Ending June 1; New Work Proposed.—A Gas and Electric Light Fixture Trust.—Another Explosion in the Subway; Inquiry Into its Cause.—Estimated Annual Leakage of Gas.—The Habeas Corpus Proceedings in Behalf of Kemmler; Taking of Expert Testimony.—New Bids for City Street Lighting.—Death of Foreman Quinn at the Elizabeth Street Brush Station.

THE Board of Electrical Control have been laboring industriously to find something to do without making a mess of it, and the position of that body may now be defined as permitting the stringing of wires in subways only; and in absence of subways the board will order them laid. However, an order for a subway will bring very little consolation to the electric light companies which are branching out for new business, as it is estimated that it will require at least a year to complete a fresh order, the contracts now on hand sufficing to keep the subway company busy for many months to come. The mayor declares that the subway company are negligent, and tells them to construct subways of full capacity without delay, and the board will fill them. The attorney of the subway company suggested issuing a circular letter to each of the local companies asking if they had any preference for a particular system or material for subway use; and following this up with a meeting of representatives from each company for the purpose of formulating a comprehensive subway scheme for the entire city. The United States Illuminating Co. requested permission to use its own conduit—on a system which they control. They claimed the privilege to use their own conduit on the ground that the Edison company possess that right. Commissioner Gibbens's resolution for subways in 3d avenue from Chatham square to Harlem river and in Broadway and East 42d and 59th streets will be carried as soon as the board decides upon the material to be used. A suggestion that a subway be constructed embodying all of the different systems, so that an equitable and practical test may be made does not meet with favor. It follows very naturally that they are as far as possible passive upon all matters. The engineer of the Subway company estimates that the new subways ordered will cost $1,200,000 and of 325 miles in length. Dr. Schuyler S. Wheeler, expert of the board, reported that there had been 1,494 miles of wire, and 2,417 poles removed during the year ending June 1.

1. *Jour. Phys. Soc.*, vol. ix., p. 208.

Chief Engineer Beckwith, of the construction company, reported that of the 40,000 feet of telegraph and telephone subways authorized previous to the present year, 10,000 feet were completed and in progress, and of the 189,600 feet of electric light ducts authorized 14,000 feet were completed or in progress. Of the subways ordered in 1889, aggregating 480,900 feet, 195,000 feet had been completed. The total subway work performed by the company since May was 250,000 feet. The board also ordered the construction of a subway on Broad and Nassau streets from Exchange place to Pine street.

The particulars of a trust or pool formed by prominent gas and electric light fixture manufacturers were sent from Philadelphia on July 14. The manufacturers claim that competition has been so fierce that their goods have been sold at a loss, and they found it necessary to combine to protect their interests. The associated concerns are called the Association of Gas and Electric Light Fixtures, with headquarters in Philadelphia.

Two explosions of gas in the subways took place at 7.30 P. M. on July 19; one of these explosions being at the man-hole at the corner of 20th street and Broadway, the other following very soon afterwards at the corner of 19th street. Although naturally causing great excitement, no one was hurt or injured in the least. The usual examination and inquiry was made by the Board of Electrical Control on the day following. It was found that the wires of both the Manhattan and Brush companies were alive at the time of the explosions, but the insulation and connections were found intact. There is consequently no direct evidence in this case—as in others which have been investigated—that the explosions were caused by electric sparks, and the commissioners as well as the expert of the board believe these explosions to be caused by the admixture of gases.

The chemist of the Board of Health estimates the leakage of illuminating gas from the pipes at nearly 100,000,000 cubic feet annually. A system of blowers is in operation daily, one at the Marlborough Hotel and the other at the Telephone Building in Cortlandt street in connection with blowers operated by hand; but the leakage is so great that the method adopted is by no means effective.

Hon. W. Bourke Cochran, of counsel for Kemmler the sentenced murderer, in whose behalf a writ of habeas corpus was issued on the ground that death by electricity was a cruel and unusual punishment, and counsel for the state have been taking testimony before Mr. Tracy C. Becker, who was appointed referee. The proceedings were begun July 8, at Mr. Cochran's office in the Equitable Building, the first witness being Mr. Harold P. Brown. Mr. Brown was followed by Mr. F. W. Jones, of the Postal Telegraph Co., Mr. F. L. Pope, Mr. Elbridge T. Gerry, the author of the bill, Mr. Gibbens, one of the commissioners of the Board of Electrical Control, Mr.. T. Carpenter Smith, of M. R. Muckle & Co., Philadelphia, and others. Mr. Brown contended that as the velocity of nerve action was about 170 feet per second, while that of electricity a million times as great, death by the electric current must be painless, as the nerve centres would be paralyzed long before the sensation could reach the brain. He held that the average resistance of a human being was 2,500 ohms, but that he had provided each equipment sold to the state with a Wheatstone bridge, whereby the resistance of the subject could be measured by passing a current so feeble as to be imperceptible. Mr. F. W. Jones stated that at one time while experimenting upon himself with a 10-cell battery, his resistance dropped from 80,000 to 16,000 ohms in 10 minutes. He regarded Mr. Brown's experiments of little practical value. Mr. F. L. Pope testified to having made some recent experiments upon himself which showed a variable resistance under different voltages.* This was due, he conjectured, to the chemical action of the current upon the fluids of the body. This variation necessarily affects the reliability of the Wheatstone bridge as a measurer of human resistance. The evidence thus far adduced being sufficient to excite grave doubts as to the possibility of measuring accurately a criminal's resistance, the Referee, Mr. Becker secured permission to make a personal investigation for himself at Mr. Edison's laboratory. In company with counsel and other interested parties the referee repaired to the laboratory, where a number of experiments were carried out fully substantiating the results obtained by Mr. F. W. Jones and Mr. F. L. Pope. A number of witnesses testified to having received the full force of a current from a machine similar to the ones Mr. Brown sold to the state. The state will follow with the testimony of several physicians who were with Mr. Brown at the time the experiments were made upon animals at Mr. Edison's laboratory. The testimony must be completed and ready for the court by July 30, when the court will hear the arguments on a motion to adjudge the constitutionality of the statute.

The former bids for city lighting having been rejected by the gas commission on account of alleged excessive prices, new bids were invited resulting in very much lower rates than asked for previously. The prices were as follows:—

United States company—282 lamps at 25 cents a night, 176 at 29 cents and 334 at 35 cents. Brush company—371 lamps at 35 cents and 70 lamps in the subway districts at 45 cents. East River company—387 lamps at 35 cents and 21 lamps in the subway districts at 44 cents. Mount Morris company—378 lamps at 20 cents, 139 at 21 cents, 72 at 22 cents, 94 at 23 cents, 32 at 24 cents and 22 at 25 cents. Harlem company—49 lamps at 35 cents, 16 in the subways at 44 cents, 19 in Mount Morris park at 50 cents and two on the Harlem bridge at 60 cents. North New York company—26 lamps at 40 cents and 3 on the Harlem bridge at 60 cents.

Edward Quinn, foreman of the Brush Electric Illuminating Co., was almost instantly killed June 27 while endeavoring to remedy a faulty connection.

NEW YORK, July, 1889.

BOSTON.

The West End Railway Company's Contract with the Thomson-Houston Company.—An Ordinance Permitting Increased Speed on Street Railways.—Other Street Railway Notes.—Electric Power Notes.—Flash Light Time Signals.—The Government Suit against the American Bell Telephone Co.

THE West End Street Railway Co. makes an official announcement of its action in connection with the electric system in these words:—"We have adopted the Thomson-Houston system because we find it is the best suited to our needs. The contract between the West End and the Thomson-Houston for furnishing motors and for the supervision, maintenance and repair of them and of the overhead line is an excellent one for the West End company, inasmuch as it eliminates nearly or quite all of the unknown quantities in the matter of changing from horse to electric power, and enables us to determine very accurately the cost of equipping and operating the road by the electrical system. The ability to go faster constitutes a considerable saving in time and expense. The total apparent saving will be very large, and the contract acts as a guarantee for dividends on the stock which it is necessary to issue for changing the system and for further expenses in providing some new means of transit through the crowded parts of the city which the company is contemplating. The contract is also an excellent one for the Thomson-Houston company, in that the prices fixed for maintaining the electrical equipment are based on their own experience, and are ample for the service rendered. Furthermore, the direct care and oversight by the Thomson-Houston company will sooner bring the details of the electrical apparatus to perfection, and will be of importance to us and to them in their extensive business elsewhere. There has been considerable delay in settling the many details of the contract, but the company will now push forward its work of construction with vigor."

The railroad commissioners have granted the West End Street Railway permission to use the electric overhead system on its Boston and Cambridge lines, and to make the necessary underground and surface alterations.

At a meeting of the board of aldermen on the 19th of June, the committee on railroads was requested to consider the expediency of amending the standing regulations of the board of aldermen so that the rate of speed for street cars may be increased from seven miles per hour to 15, and also to consider the expediency of further amending the rules so as to permit "tow cars" to be used in the streets of the city in connection with electric cars.

The new electric line from Revere Beach to Winthrop Junction was tested on the 1st, and although no formal notice of the opening of the line had been made, the cars were well filled. By means of a transfer from the Ocean Pier the passengers from that section were enabled to secure a continuous ride from that section for a single five cent fare to Winthrop Junction, where close connection was made with the East Boston cars. It is intended that by means of the combination of these two lines passengers will be enabled to make the entire ride between the Beach and any point in Roxbury reached by the East Boston cars for 10 cents, and to any point in the West End system not reached by them for 13 cents.

It is announced that electric cars on the North avenue, Cambridge and Arlington lines will take the place of the horse cars. In order to secure rapid transit, regular stopping places about a quarter of a mile apart have been established.

The Beverly selectmen gave a hearing on the 6th of July, on the application of the Foster-Robinson Electric Co., to establish a plant and furnish power for manufacturing purposes. President Whiting was present, and the company's electrician, Mr. Cahoon, stated that their agent had canvassed the town and had guaranteed 15 h. p. Hon. John I. Baker, representing the Beverly Electric Light Co., opposed the introduction of the new plant, and said the local company would furnish power within 10 days if they were guaranteed 5 h. p. The selectmen will take the matter under consideration.

It is rumored in Salem, that the Robinson-Foster Electric Motor Co., whose works are at South Peabody, and whose stockholders are principally Salem people, charge that a former official of the company has disposed of a large block of the stock, making returns at $1 per share, while he only had authority to sell at $3. It is claimed that the loss caused by this move has been nearly

$10,000 to the company, and a suit in equity has been brought by one of the largest stockholders and an injunction served on the person in question and on the company to prevent any transfer of the stock.

The flash-light signals on Blue Hill, during the first week of the month, have attracted much attention from residents in neighboring cities and towns, and Mr. W. P. Gerrish, of Harvard College Observatory, the inventor of the system, has received encouraging letters from various points about Boston, where the flashes have been seen. Among others, notes have been received from Hotel Pemberton, at Hull, and from Norwood and Lynn. This is the farthest point heard from as yet, a distance something more than 12 miles.

These signals are of the same nature as the time ball and electric fire alarm signals, but are not intended in any way to supplant them, but will give to the towns within a radius of 15 miles of Boston, a correct time signal each day. The signal is given at 10.15 o'clock each night, and consists of a charge of magnesium powder of 20 grains, which, when fired, gives a bright flash of white light. At present, as there is no telegraphic communication between Harvard and Blue Hill, the signal has to be fired by hand, thereby causing an error of a few seconds, but eventually, if put into practical use, the signal will be fired automatically by telegraph from the observatory at Harvard College, thus reducing the loss to a few hundredths of a second.

The Newton city council's session on the 2d inst., was prolonged until two o'clock the next morning, by a discussion of the comparative merits of the Wilson and Gamewell police signal systems. The aldermen voted four to three, to adopt the Wilson system, and the common council voted not to concur with the aldermen. The contest over the adoption of a police signal system has been going on for more than eight months.

The Electric Club, organized here a year ago, has further developed the New England Electric Exchange, by obtaining a charter, and the formal inauguration took place a few days ago, in an elegant suite of rooms, including a billiard and pool room, a dining room, with servants, and a large lecture and reading room and library, at 7 Park street. P. H. Alexander presided and delivered an address on the work which had been accomplished during the quarter. Resolutions were adopted transferring the property of the old and unincorporated exchange to the new organization. More than 200 men have now been examined as to their knowledge and experience in electrical work, with the result that much better work is being done, and public confidence in electric lighting is on the increase.

Judge Colt gave a decision on the 2d inst., in the case of the United States *vs.* The American Bell Telephone Co. *et al.*, denying the defendant's motion and granting the plaintiff's motion for an examiner, and appointing Henry L. Hallett, examiner. Among other things the rescript says:—"The defendant's motion seeks in effect to restrict the testimony by order of the court to the single issue of fraud which is raised by the plea. It is certainly unusual upon a motion made in the ordinary way for the appointment of an examiner to ask the court by an interlocutory order to limit in advance the scope of the testimony to be taken. It would seem probable that no appeal would lie from such an order. * * * The fact that this is an important and in some respects an exceptional case should not prevent the court from following the usual and ordinary course of equity practice." The point at issue was whether the examiner should take testimony covering the case at length, as the plaintiff desired, or only that relating to alleged fraud on the part of the defendants. The defendants desired that the testimony be limited to the latter extent.

On the 9th, Judge Colt granted an extension of three months, within which the government may take testimony in the case.

The New Redding Electric Co., of this city, was incorporated in April, with a capital stock of $100,000 in 20,000 shares, at a par value of $5 per share, Harvey Redding, president; Jerome Redding, treasurer.

BOSTON, July 16, 1889.

CHICAGO.

The Proposed University.—Mr. H. Ward Leonard's Appointment.—The Sale of the Van Depoele Electric Co. to the Thomson-Houston Electric Co.—A new Electric Supply Manufacturing Company. Electric Lights in the Chicago Theatres.—The "Ticker" Controversy on the Board of Trade.—Arrest of a Machinist on a Charge of Complicity in the Electric Sugar Swindle.—Prosperity of the Chicago Electric Club.—The Elevated Railway Question still being Agitated.—Return of City Electrician Barrett.—Fire Destroys the Plants of Three Electric Manufacturing Concerns.—Electric Light Interests at Hyde Park and Lake View.—Electric Railways for Joliet and Quincy.—Electric Motors in Chicago.

IN the last Chicago letter appeared a brief reference to the munificent offer of John D. Rockefeller to give $600,000 for the establishment of a university in this city, provided that the Baptists raise $400,000 for the same purpose. In an editorial note treating of this subject, the question was asked by THE ELECTRICAL ENGINEER, "Why the Baptists?" The editorial furthermore set forth the advantage of a non-sectarian institution. The writer is not in a position to speak for the Baptists, but his acquaintance with the facts, perhaps makes him competent to answer the question. The Baptists took up the matter simply because no other body would interest itself in it. Propositions to found an institution of learning in Chicago on a non-sectarian basis after the collapse of the University of Chicago, have failed to awake the slightest interest in the city. The Baptists consequently hammered away at their scheme. Whether an undenominational school is better adapted to promote the cause of secular learning is another matter entirely. This explanation is simply given to show why the Baptists have taken hold of it.

The appointment of H. Ward Leonard, of the firm of Leonard and Izard, Chicago, to the position of general manager of the United Edison Manufacturing Co., of New York, was a decided surprise to that gentleman's friends in this city. The appointment was somewhat in the nature of a surprise to Mr. Leonard himself. Ten days before he left Chicago to begin his work in New York, he had not the slightest intimation that he was to become a metropolitan general manager. Mr. Leonard has many friends in Chicago, who were extremely sorry to see him leave the city. He is a bright, wide-awake young man who makes his influence felt wherever he goes. He was an active member of the Chicago Electric Club, and to its literary meetings contributed a number of excellent papers. His friends gave him a farewell dinner at the rooms of the Chicago Electric Club. In 1887, Mr. Leonard formed a co-partnership with E. M. Izard, and from the beginning the firm has been most successful. Last month the firm was succeeded by the Leonard and Izard Co. Mr. Leonard will retain the presidency of the company, and the active management will devolve upon W. S. Andrews. The latter is popular in Chicago, and his friends will be glad to see him again in the local electrical circle.

During the last month the Thomson-Houston Electric Co. purchased the entire business of the Van Depoele Electric Co., of Chicago. The motor business of the company was purchased by the Thomson-Houston company in March 1888. It was thought then that the disposal of the remainder of the business to some aggressive corporation was only a question of time, The Van Depoele company continued its business longer than was anticipated. How much was paid for the transfer of the electric light business has not been made public. When the factory here is to be closed down has not been decided by the purchasing company. George A. Mayo, who has been the electrician of the Van Depoele company for the last eight months, will establish an electrical factory at Rockford, Ill. He will manufacture supplies, it is understood, covered by patents owned by him. The incandescent system which the Van Depoele company introduced a few months ago was designed by Mr. Mayo.

In several theatres in Chicago at the present time the electric lights play an important part. It is customary for several managers to place productions of a spectacular character on the boards during the summer months. Each year more lavish use is made of electric lights and each year the stage electricians learn how to manipulate the lights to better advantage. The effects which are now employed are marvelous in their beauty. In several scenes in one of the spectacles the stage presents a picture which is fairly bewildering in its dazzling brilliancy. In the "Tempest," which is now produced at a local theatre, the electric light effects are unusually brilliant. The lightning especially, which flashes from a dark bank of clouds is realistic and fairly startles the spectators. Another pretty effect is the representation of the weird light of the moon behind a fleecy mass of clouds. Most of the theatres in the city are now lighted by electricity. All those of any prominence will be so lighted at the beginning of next season.

The "ticker" controversy has recently excited the members of the board of trade. The board proposed to shut off quotations by the ticker, but the proprietors of the bucket shops appealed to the court. It was held by the court that the board could stop furnishing quotations for tickers, but if so, it must abolish furnishing quotations entirely. All must be treated alike, for if quotations were furnished at all, they were a sort of public property. It was proposed then to furnish quotations every 15 minutes, but this compromise was not allowed by the court. Finally the board was compelled to admit that it was beaten, and the directors acknowledged that they had exhausted all their expedients to cripple the bucket shops. The advisability of shutting off quotations entirely was considered, but it was thought this policy resembled too much that of cutting off one's head on account of a boil on the neck, and now the quotations are transmitted without control.

Samuel B. Leach, a machinist residing in Chicago, was arrested July 3, on the charge of complicity in the electric sugar swindle. He is alleged to have obtained money by a conspiracy with the fiends, in accordance with which he was represented as the only mechanic in the country competent to work the electric sugar machinery. He was discharged from custody when it was shown to the court that the grand jury in New York had adjourned without indicting him.

The Chicago Electric Club rooms are becoming the scene of many an enjoyable banquet. That given in honor of H. Ward Leonard has been noted. On July 10, a number of club members arranged a dinner to celebrate the return from the east of S. A. Barton, the president of the club. It was a most enjoyable occasion.

J. M. Hannahs, known as the inventor of the elevated electric railway system which bears his name, says that he hopes to have 40 miles of road in operation in Chicago within a year The cost, according to his estimate, will be $300,000 per mile. He proposes to begin work he says, as soon as the council gives him permission, but there is no immediate prospect that the coveted franchise will be granted. Chicago people want elevated railways, but the owners of property on each thoroughfare desire the construction of the elevated structure on some other street.

City Electrician Barrett has returned from his trip of inspection throughout the east. He has been in search of improvements to embody in the new stations which the city will build. Work on the conduits is progressing rapidly. The contracts for poles and piping will soon be let. The electrical apparatus will be selected last.

The Burton Block, corner of Canal and Van Buren streets, was destroyed by fire in the early part of the month. Three electrical manufacturing concerns lost their plants. Elmer A. Sperry & Co. lost about $7,500 on tools and machinery. The Belding Motor Co. lost several thousand dollars, and the loss of the Standard Electrical Co. is estimated at several hundred dollars.

The project of lighting Hyde Park by electric light has come to a standstill of a sudden. Annexation and the underground question may be assigned as the causes which combine to prevent the immediate illumination of the district. The village trustees advertised for proposals and bids were all in when the annexation problem had to be faced. The Chicago authorities protested against overhead circuits on the ground that the village would be in a few days a part of Chicago, in which overhead circuits were not looked upon with favor. The bids were all in, however, and there was no time to readvertise so the matter was dropped.

The Western Electric Light and Power Co., of Chicago, will soon commence the erection of a plant in Lake View, a suburb of Chicago, which has just been annexed. About 150 arc lights will be installed at first. The Thomson-Houston system will probably be used. The franchise provides that the company shall not be obliged to bury its circuits for five years. W. H. Talcott is president and manager of the company.

The Thomson-Houston Electric Co. has closed a contract to equip the Joliet, Ill., street railway with electric motors.

Quincy, Ill., papers are clamoring for the installation of an electric railway in the city.

A. L Ide & Son, of Springfield, have received the contract for installing an electric light plant in the state capitol.

The C. & C. Motor Co.'s Chicago office has installed a 15 h. p. motor in a printing establishment in Chicago. It takes the place of a 35 h. p. steam engine. It is predicted that in a few years the motor men in Chicago will have a rich field in supplying motors for press rooms in the city. Each successful installation helps the trade.

CHICAGO, July 20, 1889.

PITTSBURGH.

Prospective General Abandonment of Horses on Street Railways.—Removal of the Westinghouse Electric Co.'s Offices at Pittsburgh.—A New Glass Factory; it will Make a Specialty of Electrical Work.

THERE appears to be a perfect epidemic of anxiety for rapid transit among the many street car corporations of this city. There is not a single street car line here to-day of which the managers are not contemplating electricity or the cable system as the future motive power of their lines. There are about 15 street car companies in Pittsburgh and Allegheny, and among these are two cable roads, the Fifth Avenue Traction Co. and the Citizen's Traction Co. Electricity is being used on the Observatory Hill Passenger Railroad and on the Knoxville Electric Railroad. The Central Traction road is nearly completed. The Pleasant Valley Railroad is putting up poles and overhead wires for the Sprague Electric Railroad system; the Squirrel Hill Railroad will also be an electric road, and the other street car companies are still discussing the merits of the various systems of motive power. One thing seems to be certain, namely, that a horse car will be a thing of the past in Pittsburgh before another year has elapsed.

The offices of the Westinghouse Electric Co. were removed a few days ago from the company's works on Garrisson alley, into the new Westinghouse building on the corner of Penn avenue and Ninth street. The electric company occupies the seventh floor of what is now the finest and largest business building in this city. Mr. Albert Schmid, the superintendent, and Mr. Nicola Tesla are the only two gentlemen who have retained their offices in the Garrisson alley building.

The change was necessitated on account of the want of room at the electric works, and the premises now vacated by the offices will be changed into workshops in a very short time.

The already numerous industries of Pittsburgh are shortly to obtain a further acquisition in a new glass factory, which is to be erected in Wilmerding, a suburb of this city. At this establishment all kinds of glassware used in the electric business, especially globes, are to be manufactured. There will be 200 men employed at the factory, and about 30,000 globes are to be produced every day. Mr. Reinman, formerly superintendent of the globe department in the Westinghouse Electric Co., is one of the principal stockholders in the concern.

The East End Electric Light Co., which secured the contract from the city authorities to light the City of Pittsburgh with electric light, has about completed its contract. The 500 arc lamps, which had been contracted for have all been put up, and the company is now occupied putting up 2,500 incandescent lamps for the smaller thoroughfares. During the last week, however, a halt seems to have been called in the work, for the reason, that the fathers of the city are earnestly contemplating the advisability of lighting the city exclusively with arc lights. A decision in this matter will be made at the next meeting of the board of awards.

An adjourned meeting of the Westinghouse Electric Co. took place a few days ago for the purpose of substituting a new charter for the one under which the corporation hitherto has been operated. Owing to the enormous proportions to which the company has grown since its organization, the old charter has proved insufficient for its requirements, and hence the change was proposed by Mr. Westinghouse.

Over three-fourths of the stock was represented at the meeting, and after Mr. Westinghouse gave his reasons why he deemed a change of charter advisable, his proposition was adopted by a unanimous vote.

When the company was first organized the organizers took out an ordinary charter covering the requirements of such a corporation. But since the concern has grown to such enormous proportions so as to make the old charter utterly inadequate to the demands of the increased interests of the firm, and Mr. Westinghouse has constantly been on the alert to fill the want of his company. The charter secured formerly belonged to the Chartier's Improvement Co., which is a document covering all the requirements of a large company in the broadest manner.

PITTSBURGH, July 17, 1889.

TORONTO.

An Underground System to be Put Down by the Edison Company in Toronto.—Burning of the Federal Telephone Exchange at Montreal.—A Long-Distance Light and Power Plant at Three Rivers.—Contest for Public Lighting at Hamilton.—Thornberry & Co. Contract to Light the New Bank of Commerce Building.—An Increase in Local Postage Rates Induces a Telegraph Company to go Into the Postal Business.—Telegraph Litigation.—Street Railway Notes.—A New Central Station Plant at Montreal.—Another Niagara Falls Enthusiast.

AT a recent meeting of the board of works, representatives of the gas company who propose to operate the Westinghouse system appeared, asking that the same privilege be extended to them that has been granted the Toronto Incandescent Electric Light Co. (Edison).

Mr. E. W. Johnson appeared also on behalf of the Ball Electric Light Co., stating their desire to enter the field also. If all the enterprises on foot, or on the way, mature, Toronto ought to be well lighted—electrically.

The underground question has been decided for Toronto by the council allowing the Edison company permission to proceed, but putting them under great restrictions. The by-law is so constructed that it will prevent any other company doing an incandescent business until 1892, practically giving the Edison company a monopoly until then. They will have an excellent field, and are to proceed at once with their station, a site having been obtained for a permanent building.

The new Federal Telephone Exchange at Montreal has been burned, by which a fine Law switch-board, only recently completed, was lost. It is peculiarly unfortunate, as the company has been organized but lately, and they were just getting the exchange in working trim. The fire is supposed by the fire department officials to have been caused by heavy currents, and will be investigated by the city electrician, Mr. Badger.

A company has been formed at Three Rivers, Quebec, to operate an electric light and power plant from a waterfall sixteen miles away. It is proposed to supply arc and incandescent lamps and electric power. This scheme, if carried out, will include the transmission of current to a greater distance than has been heretofore attempted in Canada. The Quebec and Levis Electric Light Co. transmit seven miles a current supplying arc and incandescent lights at Quebec.

The city of Hamilton is just now interested in a proposed contract for lighting their streets. The Heisler company and the local

company seemed to have the matter between them, but tenders recently opened indicate a disposition on the part of the gas company to compete for electric, as well as gas, lighting. They tender to supply arc lights of 2,000 c. p. at 28 cents per night. The local company's tender was for lights the same as they now have in use at 30 cents per night. The board recommended the acceptance of the gas company's tender. It seems the recommendation of the board of works has, however, stirred up considerable public feeling, and as yet the council has done nothing. The citizens object to giving the electric lighting to the gas company, as it would practically close out the electric light company.

Thornberry & Co. report their having been awarded the electric light contract for the new Bank of Commerce building, Toronto. This building is fireproof, and considered the finest piece of architecture in Toronto.

The postal authorities a short time ago increased the postage on drop letters to two cents. The result was to induce the telegraph company (Gt. N. W.) to go into the business of delivering letters. A few days ago a writ was served, at the instance of the postmaster-general, upon the Hamilton manager of the Great Northwestern Telegraph Co., claiming $25,000 damages, the postmaster claiming for the Dominion government the exclusive privilege of such delivery.

The suit between the Great Northwestern Telegraph Co. and the Montreal Telegraph Co. has advanced a step. The Great Northwestern Co. have proffered partial payment of rentals, and the money has been received by the Montreal Telegraph Co., but the payment of $41,000 is without prejudice to either party, the remaining $10,000 being deposited in a Montreal bank until a decision has been secured in the case.

The city of Stratford has been agitating the question of an electric railway, as has Kingston.

A central station enterprise has been organized by Louis, Parrault and others of Montreal. The plant is under the management of Mr. W. R. Kimball, and he reports a successful start. They have 600 lamps capacity. A 10 h. p. motor has been installed in connection with the plant at the Mongenais and Boivins glass works.

Toronto is nothing, if not abreast of the times. The proper thing now is to utilize Niagara Falls—not the American side—and Colonel Gzowski, of this city, a civil engineer, and president of the Canadian society of civil engineers, proposes to rent space from the Queen Victoria park commissioners as a site upon which to erect a power station. The details have not yet been completed; but it is proposed to export a portion of the current for the use of the Yankee—whatever may be left when Toronto and other smaller towns may be supplied. The government expect a rental of $35,000 for the privilege the promoters ask for.

Americans who have shown considerable interest in accounts of the decision recently given by the commissioner of patents at Ottawa, in the suit of the Sawyer-Man *vs.* Edison company, will learn with considerable surprise that that decision has been declared null and void. The explanation is that the commissioner of patents has never been vested with authority to sit in such cases. The commissioner of agriculture, or his deputy, it seems are the only proper authorities before whom such a hearing may be had. It is understood that the government have ordered a new hearing before the commissioner of agriculture, and it is presumed the government will have to pay all the expenses of the first hearing.

TORONTO, July 20, 1889.

LITERATURE.

History of the Transformer. By F. UPPENBORN. Translated from the German. London and New York: E. & F. N. Spon, 1889.

THIS excellent little brochure of 60 pages is exactly what its title indicates, a history of the evolution of the transformer from the discovery of the principle of electric induction by Faraday in 1831, to the invention of the non-polar transformer by Zipernowski, Déri and Blathy in 1885. While Mr. Uppenborn has obviously written this pamphlet with the object of crediting the above-named inventors with the honor of having been the first to propose the method of operating non-polar transformers on the parallel system of distribution, he has not failed to give to their ingenious predecessors in that field, such due credit as seems to him justifiable.

After the splendid discoveries of Faraday, the seeds of whose labors will continue to bear fruit until the end of time, we find that our own Dr. Henry and Professor Page made the next improvements in the construction of the induction coil. Callan, Ruhmkorff and the Bright brothers continued to improve the instrument until Jablochkoff and others, about the year 1878, found it in a sufficiently practical form to be considered as a basis for systems of electrical distribution. Among the workers in this field was another American, Jim Billings Fuller by name, to whose inventive genius the author pays a high tribute, although his own countrymen seem likely to forget his worth.

After describing the secondary generators and quasi systems of distribution of Edwards and Normandy, Gordon and others, the first industrial employment of the series system by Gaulard and Gibbs in 1883, is described very fully, although many of their claims are disputed. Whatever the justice of the grounds of dispute may be, it may be said that Messrs. Gaulard and Gibbs, as pioneers in the industrial applications of principles undoubtedly destined to revolutionize the electric lighting industry, are entitled to rather more praise and credit than has been allowed to them by Mr. Uppenborn. The criticisms of Rankin Kennedy and of Professor Colombo and others regarding the practicability of the series system are quoted at some length, and are undoubtedly sound in many particulars.

In next discussing the question as to what conditions are necessary to constitute a practical system of current distribution by means of transformers, the views expressed by Marcel Deprez some years ago are upheld, and it is shown that the Zipernowski Déri system, which is then described, fulfills all requisite conditions.

The translator has modestly refrained from giving his name, and with the exception of a few idiomatic lapses has accomplished his task in a commendable manner. Non-linguistic readers might have been a little better pleased, however, if certain patent claims, quoted in the original French and German, had been given as foot notes, with the translation in the text. To those who are either familiar or unacquainted with the history of the evolution of the modern converter we may safely commend this reliable and instructive little essay.

RECENT PUBLICATIONS.

Proceedings of the National Electric Light Association at its Ninth Convention. Annual Meeting held at Chicago, Ill., February 19, 20 and 21, 1889. Volume vi. Boston: *Press of Modern Light and Heat.* 8vo., cloth, 261 pp.

Cable Telegraphy and the Delany Line Adjuster, by Patrick Bernard Delany (reprinted from the Journal of the Franklin Institute, July, 1889). 8vo paper, 28 pp., illustrated.

Incandescent Wiring Hand-Book, with 35 illustrations and five tables. By F. B. Badt, late First Lieutenant Royal Prussian Artillery. Chicago: *Electrician Publishing Co.*, 1889. Cloth, 32mo., 66 pp.

CATALOGUES AND PAMPHLETS RECEIVED.

Messrs. Herman J. Jaeger & Co., 45 John street, New York, send us their Illustrated Catalogue and Price List of Scientific and Electric Glass Apparatus and Instruments. The list covers a wide range of practical and experimental appliances, and the illustrations and descriptive matter afford ample guidance to intending purchasers.

The C. & C. Electric Motor Co. send us an unusually handsome circular containing an instructive article on electricity applied to manufacture, illustrated by numerous engravings, showing interior views of their own factory, in which power is distributed to all the machinery through electric motors. This part of the circular forms a useful object lesson in the application of motors. The pamphlet gives also some account of the various uses to which the company's motors have been put, together with directions and suggestions for the use of purchasers. Illustrated descriptions of the C. & C. motors for both arc and incandescent circuits are also to be found, together with a variety of tables useful to the mechanical and electrical engineer.

Some friend has taken the trouble to send us a circular entitled Modern Architecture, issued by the Michigan Stone Co., of Chicago. While this circular, consisting of some 20 sheets tastefully tied in covers, is intended apparently to direct attention to the handsome building material furnished by the Michigan Stone Co., it is well worth preserving by those fortunate enough to receive a copy, for the series of engravings of elegant residences and public buildings presented as examples of the use of the Michigan green-buff sandstone. The views of the Museum of Art, Detroit, and of the Public Library, Toledo, are especially impressive and interesting.

NEWS AND NOTES.

COLLEGE NOTES.

Ohio State University.

The increase in the work at the Ohio State University has led to the retaining of F. L. O. Wadsworth, E. M., '88, and B. Sc. and M. E. '89, as an additional assistant in the department of physics under Dr. B. F. Thomas. Mr. Wadsworth has already attracted attention for his character and attainments, is an indefatigable student, and will be heard from. Together with H. L. Kirker, B. Sc., '89, he has designed and constructed an alternating dynamo of the Mordey type, of 6,000 watts capacity, which is now ready for test. Delay in obtaining material prevented its completion before Commencement in June.

H. S. Newton, B. Sc., '89, has examined the curve of impressed electromotive force of the Westinghouse alternator, and finds that on open circuit, or on closed circuit through non-inductive resistance, two indentations appear near the top and near the bottom of the curve. With circuit closed through loaded converters the indentations disappear and the curve is almost exactly a sine curve.

A. N. Ozias, B. Sc., '89, has reviewed the work of Hertz on Electric Oscillations.

The University has received two new instruments which are highly prized. One is a set of resistance coils from the Mather company, by Professor Wm. A. Anthony, of the form described by him in the *Electrical World* last year. Its arrangement is

very convenient, enabling one to do what can not be done by any other one set of coils. Dr. Thomas has found them especially convenient in the determination of the conductivity of copper rods, and he thinks them superior to anything that he has hitherto seen. The other is a Sir Wm. Thomson ampere balance, 1 to 100 amperes. It reached the laboratory in perfect order, and agrees very closely with the standards already in use.

The new electrical laboratory building is progressing rapidly and the whole will be ready for use on the opening of the new college year, September 11.

University of Michigan.

The Board of Regents, of the University of Michigan, Ann Arbor, have authorized a course of study leading to the degree of Bachelor of Science in Electrical Engineering. This course will be parallel with those in civil, mechanical and mining engineering, with the same requirements for admission, and will be under the direction of Professor H. S. Carhart.

The new physical laboratory has six rooms, specially designed for electrical and magnetic work. It is already provided with apparatus for electrical measurements by the best European makers; also with electric motors, a complete electric lighting plant of 50 lamps, and a storage battery of 31 cells. Additions to these appliances will be made at once.

The course of study will include five courses in mathematics, four in French and German, one in English, three in general physics, two in chemistry, four in drawing, one in civil engineering, eight in mechanical engineering, and at least four courses in electrical engineering. The remainder of the work necessary to graduation will be elective, and a satisfactory thesis will be required for a degree.

The first three years of the course will be nearly the same as in mechanical engineering. Besides the preliminary work in mathematics, language, drawing, and physics, instruction will be given in pattern making, metal work, forging and foundry work in the mechanical laboratory; and enough of the study of steam engines and other prime movers will be included to meet the needs of the professional electrical engineer.

The special electrical courses, additional to the elementary study of the subject, will be devoted to primary and secondary generators, electro-metallurgy, electrical units and methods of measurement, dynamo-electric machinery, arc and glow lamps, photometry, and the distribution of electricity and transmission of power. In addition, elective courses in mathematical electricity will be offered, and the student will be advised to avail himself of such opportunities.

The laboratory work in electricity will be devoted mainly to the investigation of primary and secondary batteries, to practice in making electrical measurements of precision by all the best methods, to setting up and testing dynamos, motors and storage batteries for efficiency, to photometry of both arc and glow lamps, and to special investigations connected with the preparation of a thesis.

Occasional complete tests of central electric light and power stations will be undertaken; and the student will be made acquainted with the best practice in electrical manufacturing and engineering by visits to places where such enterprises may be seen on a large scale.

Further information can be had by addressing, Jas. H. Wade, Secretary, Ann Arbor, Mich.

THE ST. LOUIS ELECTRICAL EXHIBITION.

The general management of the Universal Electrical Exhibition, to be held under the auspices of the St. Louis Exposition and Music Hall Association, commencing September 4, 1889, and continuing for a period of six weeks, has been placed in the hands of Mr. Fred. H. Whipple, of Detroit, Mich. The association hopes and expects to make this electrical exhibit the greatest that has ever been held in the United States, and for that purpose practically unlimited facilities are offered for the operation and display of electrical and mechanical products.

No charge whatever will be made for space or power, and all articles will be returned on the railroads free of cost. Floor space to the extent of 75,000 square feet has been set apart for electrical exhibits. Every aid will be given exhibitors to make an attractive display.

As an educational medium, and as a means of putting the products of electric science in a business way before the people of the south and west, this exhibition offers unexcelled advantages.

Application blanks and any information that may be desired will be furnished on application to Mr. Whipple.

THE PARIS EXHIBITION.

La Lumiére Electrique says of America's exhibit at the Paris Exposition, that it occupies a space of 6,000 square meters, about one-sixth of this being reserved for science and its applications. Though a most excellent representation, the great attraction of the American department is the electrical exhibit. Mr. Edison's exhibit occupies in all 675 square meters, and consists of, 1st, a full collection of phonographs; 2d, a complete model of an underground net of three conductors, with all the necessary accessories; 3d, models of experiments of Edison on the telegraph and telephone—this comprising a collection of nearly 100 pieces; 4th, different stages in the manufacture of an incandescent lamp; 5th, a new magnetic separator for cleaning substances containing iron particles; 6th, many new machines; 7th, a group of more than 20,000 incandescent lamps forming a large mass 15 meters in height.

This whole exhibition, arranged by Mr. Hammer, is said to have cost 400,000 francs.

Among numerous electric exhibits are those of the Thomson-Houston International Electric Co. with an excellent display. The Thomson Welding Co., showing a new system for electric welding of pieces of all sizes, by means of a current of 40,000 amperes, furnished by a dynamo of 100 h. p.

The Heisler Electric Co. shows its system of public electric lighting, employing an alternating current of 3,000 volts.

The Sperry Electric Co. shows also its system and machines.

The Bell Telephone Co. exhibits its telephones, and its poles designed to carry 80 wires.

The Underground Conductor Co., of N. Y., exhibits models of different systems employed by them.

The Western Electric Co. shows the productions of its American and continental factories.

Professor Elihu Thompson contributes an exhibit illustrating his researches in various branches of electro-technic—industrial and theoretic.

The Mackay-Bennett Co. exhibits its system of submarine telegraphy.

Messrs. Bell and Tainter have sent their newest graphophones.

This completes the list of *La Lumiére Electrique*, although it says that space forbade an extensive recital of the numerous exhibitors.

RANKIN KENNEDY'S PATENT ON PARALLEL CONVERTERS.

The United States patent issued July 16 to Rankin Kennedy for a "Method of Electrical Distribution by Secondary Generators," appears to be of much importance and interest. Below are extracts from the specification and the claim in full:—

To all whom it may concern:—

In systems of distribution by alternating electric currents employing stationary induction-coils or secondary generators it was customary, prior to my invention, to connect all the primary coils in the circuit of the source of alternating currents in series. In such an organization the primary conductors of all the secondary generators are traversed in succession by one and the same current, and as a consequence any variation in the resistance opposed to the passage of the current through any one primary coil produced a corresponding variation in the current flowing through the primary coil of all the other secondary generators. It was found in practice that opening the secondary circuit of any of the secondary generators resulted in greatly diminishing the current delivered to all the others, and thus the entire system would be disturbed by turning off the lights at any one point. No entirely satisfactory method of overcoming this defect has been discovered. I have found that a counter electromotive force is set up in a coil of wire carrying an alternating current and wound upon an iron core, and this counter electromotive force is proportionate to the size of the iron core and the length of wire in the coil surrounding the core. I have also found that when the secondary circuit of a properly-constructed secondary generator is open or disconnected and an alternating electric current is applied to the primary coil a counter electromotive force is developed in the primary coil which is practically equal to the applied electromotive force. When, however, secondary currents are allowed to develop in the secondary coil, the counter electromotive force is so modified that a primary current flows which varies approximately directly as the resistance offered to the development of the secondary current. Availing myself of this discovery, I have devised a new method of distribution of energy by alternating electric currents, by which the secondary generators are rendered independent and self-governing, each receiving its appropriate current independently of all the others, and each deriving from the source an amount of energy proportionate to that which is actually consumed in the secondary circuit. In carrying this method into operation the primary coils of the secondary generators are connected with the source of energy in branch or derived circuits and the secondary coils are closed through the lights arranged in parallel arc. In such an organization each secondary generator receives its current independently of all the others, and the primary current in each secondary generator increases as the resistance in its secondary circuit decreases; or, in other words, the primary current increases as the current in the secondary circuit increases. From this it follows that the energy supplied to the primary coil or consumed by the secondary generator may be made nearly directly

proportional to the work being done, and the whole system becomes self-regulating and flexible.

When two or more such secondary generators have their primary conductors connected in parallel arc and their secondary circuits disconnected or open, the counter electromotive force is so great that practically no current passes through the primary conductors; hence when no work is being done in the secondary circuits little or no energy is wasted. When, however, the secondary circuit of any given secondary generator is closed through a greater or less number of parallel branches containing lamps or other translating devices, then a secondary current is generated in the secondary wire, the effect of which is to neutralize the counter electromotive force proportionally to the amount of work being done. These changes take place without modifying the value of the current traversing the primaries of the other secondary generators or affecting in any way the operation of the translating devices in their secondaries. The same is equally true of any of the other secondary generators or any number of them connected in the same manner, and it follows that the system is an automatically self-regulating as well as a very economical one.

The claim is as follows:—

The method of distributing and regulating alternating electric currents by secondary generators, which consists in producing in two or more derived circuits constituting the primaries of two or more secondary generators a counter electromotive force, which, when any secondary is open, is practically equal to the applied electromotive force in its primary, and in controlling said electromotive force by the current flowing in the corresponding secondary, when the secondary is closed, in such manner that the current in the primary shall vary with and be approximately inversely proportional to the resistance in the secondary, substantially as described.

MR. PARK BENJAMIN ON ELECTRICAL EXECUTIONS AND THE RECENT JUDICIAL INQUIRY.

A letter from Mr. Park Benjamin in the *New York Herald*, of Sunday, July 28, concludes as follows:—

The law does not provide that criminals shall be executed by any particular kind of current, but by electricity. It is difficult to perceive how the law can be regarded as unconstitutional until it be shown that death by electricity cannot be caused except under conditions which bring its use under constitutional prohibition.

The present inquiry does not seem to have extended beyond a consideration of the slow dynamo current produced in one form or the other. And even as to this wide divergence of opinion, partial and impartial, has been made manifest.

It has been shown that people who have received the current from electric light wires and lived have been terribly burned and mutilated. Such persons have described to me their sensations as most horrible, likening them to the agony which might be produced by red hot needles burrowing into nerve pulp. It is also shown that men and brutes have been repeatedly killed by such a current.

But there is no proof of painless death. Dumb animals cannot tell their sensations, and a man might be rendered incapable of showing the torture which kills him. A few seconds of such agony is an eternity.

There is no question but that a man can be killed by the dynamo current, and equally there is none but that he can be slowly squeezed to death in a hydraulic press. The law is satisfied by causing death, and hanging accomplishes that end already. The present object is not merely to kill, but to do so instantly and painlessly. That the dynamo current is competent to do this is most certainly a matter of doubt, and of that doubt any human being is entitled to the benefit.

The state has not tested nor taken any steps to test in any adequate way all possible modes of electrical destruction.

In common with others better qualified than I am to judge, I believe that we should imitate the terrific shock of the lightning discharge and not shake the criminal asunder by the rapid pulsation of the alternating current, nor burn him up by the slow decomposition produced by the direct current.

The state has acted negligently and precipitately. It should create a proper commission of scientists of known reputation, charged with a practical examination within a reasonable and limited time of all means of electrical execution, and in the report of that commission an argument on the constitutionality of the law might find some adequate basis. In the meantime the condemned man should not be killed by the clap-trap contrivances now at hand in Auburn, nor should the most solemn act which society can perform be prostituted to the purpose of a business advertisement.

NEWSPAPER ELECTRICITY.

It is noticed at Erie, Pa., that the electric cars make much better time after sundown and before dawn than during the day. This is, they think, accounted for by the fact that the air is then full of dampness and allows of greater electric power.—*Electrical Review* (New York).

Foreign Notes.

THE Electrical Exhibition at Birmingham, England, will be held from August 10 until October 31. Among the exhibitors will be the Edison and Swan Electric Light Co., the Anglo-American Electric Light Co., American Brush Electric Light Co., Woodhouse and Rawson, Elwell-Parker, Laing, Wharton, and Down, the Gulcher Electric Light Co., Shepley Bros., Ernest Scott and Co., the Planet Electrical Engineering Co , Fowler, Lancaster and Co., the Julien company, Julius Sax, and the Acme Lighting Co., Messrs. Robey and Co., Ruston, Proctor and Co., Galloways, and Greenwood and Batley will exhibit in the steam engine department. There will be some 200 exhibits. An electrical switchback telpherage system will probably be constructed, upon which visitors may take aerial flights in the hall.

A PROPOSAL has been made to hold an exhibition of electrical engineering and mechanical inventions in the capital of Scotland next year. Over 100 firms have signified their willingness to exhibit.

THE plan of voting in assemblies by means of the electric current, and thus avoiding the time lost in making divisions, has been before the French chamber of deputies, and a report on the subject was presented by M. Montant last December. In that report the advisability of employing a machine which would indicate not only the total votes, *pour* or *contre* a measure, that is to say, the "ayes" and "noes," but also the number of voluntary abstentions from voting, as distinct from the number of absentees. Such an apparatus has now been devised by M. Le Goazion. On every disc in front of a member is placed a small box fitted with two handles, which the member works when registering his vote. The right handle registers his "aye," the left his "no," and both moved simultaneously indicate his abstentation from voting. The results are printed by means of electro-magnets in a receiver, and are visible at a glance. Provision is made for a member to recall and correct his vote during the time allowed for the purpose.

A WESTINGHOUSE ELECTRIC COMPANY IN ENGLAND.

The organization of the Westinghouse Electric Co. Limited, is noted in the *Electrical Review*, of London, July 19, as follows:—Capital, £600,000, in £10 shares. Objects: To acquire the patents, good-will, business, and property of the American company known as the Westinghouse Electric Co., and to manufacture and deal in every kind of engine, machine, wire, lamp, or appliance capable of being used in connection with the utilization or generation of electricity. Signatories: *Sir Hy. W. Tyler, M. P., Pymmes Park, Edmonton; *Francis Pavy, Foley House, Portland Place; *John Dixon Gibbs, 18 Warwick street, Regent street; Wm. D'Oyley, 24 Westbourne Terrace (100 preference shares each); C. Colin Macrae, 26 Cheyne Walk, Chelsea; Hy. Rudolph Laing, 3 Drapers' Gardens (20 preference shares each); Hy. Turton Norton, 57½ Old Broad street (10 preference shares). The signatories denoted by an asterisk, and G. Westinghouse, Jr., and S. Humbird are the first directors; qualification, 100 shares each; remuneration, £2,000 per annum, to be divided as they may determine. Registered 11th inst. by Norton, Rose & Co., 57½ Old Broad street.

THEATRE LIGHTING.

After the electric lighting was introduced into the Hof theatre, Munich, attention was turned to the hygienic advantages of such a system, and of the comparative merits of electric and gas lighting with respect to the ventilation. The "Deutscher Verein von Gas und Wasserfachmänner" since 1885, have repeatedly offered prizes for a feasible solution of the problem of ventilating gas lighted rooms, but as yet no practical solution has been proposed. Several years ago, an experiment was made with the Royal Odeon in Munich. The Polytechnic Verein advised the replacing of a delapidated, insufficient gas arrangement, with the electric light. To the disappointment of the gas company, this advice was accepted, but for some reason the result was disappointing and the gas company was after all given the contract for an improved gas service. This was carried out, and was an undoubted improvement, but the complaints of the heat in the gallery did not cease. So insufficient was this improved gas service, that the electric company was called upon the second time to come to the relief of the suffering gallery frequenters. The proof that gas lighting in its hygienic effects can compete with the electric light, has yet to be made.—*Centralblatt für Electrotechnik.*

.... ELECTRICAL welding has given quite an impetus to many industries. At Worcester, Mass., says the *American Artisan*, the makers of a new hoop are using the process and find the saving over the ordinary mode immense, as a hoop can now be welded in two seconds. The hoop itself is of corrugated steel, for use on flour barrels, and four steel hoops now take the place of 10 wooden ones.—*Exchange.*

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Allegheny, Pa	Obs'rvat'y Hill Pass. Ry. Co.	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co	2	3	Thomson-Houston.
Ansonia, Conn	Derby Horse Ry. Co	4	1	Thomson-Houston.
Appleton, Wis.	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	20	Daft.
Asheville, N. C	Asheville Street Railway	3.5	4	Sprague.
Atlantic City, N. J	Pennsylvania R. R. Co	6.5	6	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Bangor, Me	Bangor Street Railway Co	5	4	Thomson-Houston.
Bay Ridge, Md	Bay Ridge Electric R. R.	2	2	Sprague.
Binghamton, N. Y	Washington St., Asylum & Park R. R.	5	8	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., Brookline Branch	11	23	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	20	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co	4	4	Sprague.
Buffalo, N. Y.	Buffalo, St. Ry. Co	2.5	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	1.5	3	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	3	Daft.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cleveland, Ohio	East Cleveland Railroad Co.	8	16	Sprague.
Cleveland, O.	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Cleveland, O.	Collamer Line, East Cleveland, O	3	8	Sprague.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenport Central Street Railway Co	3.5	9	Sprague.
Danville, Va.	Danville St. C. Co	2	4	Thomson-Houston.
Dayton, Ohio	White Line St R. R. Co	9	12	Van Depoele.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	10	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Eau Claire, Wis	Eau Claire St. Ry	5	6	Sprague.
Erie, Pa	Erie City Pass. R. R. Co	12	20	Sprague.
Fort Gratiot, Mich	Gratiot Electric Railway	2	2	Van Depoele.
Harrisburg, Pa	East Harrisburg Pass. Ry. Co	7.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	4	Sprague.
Ithaca, N. Y.	Ithaca Street Railway Co	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind.	Lafayette Street Ry. Co	3	9	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angelos, Cal	Los Angelos Elec. Ry. Co.	5	4	Daft.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)	1	1	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Highland Line)	2	3	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Nahant Line)	.8	1	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Marlboro, Mass	Marlboro St. Ry. Co	3	2	Sprague.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3	6	Thomson Houston.
Newark, N. J	Essex Co. Pass. Ry. Co	2.5	4	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
New Orleans, La			1	Daft m'tr and Gibson st'ge battery.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co.	14	14	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	10	26	Thomson-Houston.
Omaha, Neb	Omaha Horse R. R	10	20	Sprague.
Pittsburgh, Pa	Pittsburgh, Knoxville & St. Clair St. Railway	2.25	4	Daft.
Plymouth, Mass	Plym'th & Kingston Ry. Co.	4.5	3	Thomson-Houston.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Reading, Pa	East Reading R. R. Co	2	3	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Revere, Mass. (Ex.)	Revere St. Ry. Co	1.5	4	Thomson-Houston.
Richmond, Va.	The Richmond Union Pass. Railway Co	13	46	Sprague.
Rochester, N. Y	Rochester Electric Ry. Co.	7	8	Thomson-Houston.
Salt Lake, Utah	Salt Lake City R. R. Co	6.5	10	Sprague.
Salem, Mass	Naumkeag Street Ry. Co	2	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
Seattle, Wash. Ter	Seattle Electric Railway and Power Co	5	5	Thomson-Houston
St. Catherine's, Ont	St. Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	6	12	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	10	17	Sprague.
St. Joseph, Mo.	Wyatt Park Ry. Co. (Northern Division)	4.5	9	Sprague.
Scranton, Pa	The People's Street Ry	12	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	5	10	Thomson-Houston.
Scranton, Pa	Nayang Cross-Town Ry	1.5	3	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Southington, Conn	Southington & Plantsville Ry. Co	2	2	Thomson-Houston.
Syracuse, N. Y	Third Ward Ry. Co	4	8	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co	2.5	6	Sprague.
Stillwater, Minn	Stillwater Electric St. Ry	5	6	Sprague.
Topeka, Kan	Topeka Rapid Transit Co	17	30	Thomson-Houston.
Washington, D. C	Eckington & Soldiers' Home Electric Railway Co	3	10	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	10	Thomson-Houston.
Wichita, Kan	Riverside & Sub'ban Ry. Co.	9	6	Thomson-Houston.

Electric Street Railways in America now in operation.—*Continued.*

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Wichita, Kan	Wichita & Suburban Ry. Co.	7.5	7	Sprague.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	3	7	Sprague.
Wilmington, Del	Wilmington City Ry. Co	3	4	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	2	2	Van Depoele.

Total—Roads 88
" Miles 446.75
" Motor Cars 677

Constructing or Under Contract.

Location.	Operating Company,	Length in Miles	No. of M. Cars	System.
Adrian, Mich	Adrian Electric Railway	3		Nat. Elec. Tract. Co.
Akron, O	South Side Extension	6	10	Sprague.
Albany, N. Y	W't'rvliet T'npike & R. R. Co.	15.5	16	Thomson-Houston.
Atlanta, Ga	Atl'nta & Edg'w'd St. Ry. Co.	4.5	4	Thomson-Houston.
Atlanta, Ga	Fulton Co. St. Ry. Co	9	8	Thomson-Houston.
Attleboro, Mass	No. Attleboro & Wrentham St. Ry. Co	8	5	Thomson Houston.
Americus, Ga	Americus St. Ry. Co	5.5	4	Thomson-Houston.
Auburn, N. Y	Auburn Electric Ry. Co	3	3	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets			Bentley-Knight.
Cincinnati, O	Cinc. and Inclined Plane Ry	6	20	Sprague.
Cincinnati, O	Cincinnati St. Ry. Co	2.7	8	Thomson-Houston.
Cincinnati, O	Colerain Ave. Ry. Co.	5	8	Thomson-Houston.
Cleveland, O	B'way & Newb'ugh St. Ry.	10	16	Sprague.
Cleveland, O	East Cleveland St. R. R., Prospect St Line		32	Sprague.
Dallas, Texas	West Dallas St. R. R	3	2	Sprague.
Decatur, Ill	Citizen's Electric St. Ry	5	4	Thomson-Houston.
Decatur, Ill	Decatur Electric St. Ry	3		Nat. Elec. Tract. Co.
Detroit, Mich	E. Detroit & Grosse Pointe Ry	8		Nat. Elec. Tract. Co.
Detroit, Mich	Detroit City Railway, Mack Street line	2		Nat. Elec. Tract. Co.
Detroit, Mich	Detroit, Rouge River & Dearborn R. R	1	1	Sprague.
Denver, Col	University Park Ry. & Electric Co	4	3	Thomson-Houston.
Dubuque, Ia	Key City Electric Ry	2	4	Sprague.
Elkhardt, Ind	Citizens Street Railway	7		Nat. Elec. Tract. Co.
Fort Worth, Texas	Fort Worth City Ry. Co	10		Nat. Elec. Tract. Co.
Fort Worth, Texas	Fort Worth L'd & St. Ry. Co.	15		Nat. Elec. Tract. Co.
Kansas City, Mo.	Vine St. Ry		6	Thomson-Houston.
Kansas City, Mo	Metropolitan St. Ry. Co	4.5	4	Thomson-Houston.
Laredo, Texas	Laredo City R. R.	4	4	Sprague.
Long Island City, N. Y.	Long Island City & Newton Electric R. R	3	2	Sprague.
Louisville, Ky	Central Pass. R. R. Co	10	10	Thomson-Houston.
Lynn, Mass	Belt Line Ry. Co		4	Thomson-Houston.
Lynn, Mass	L. & B. R. R. Myrtle St. Line	3	4	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Nashville, Tenn	Main St. & Lichy Ave. R. R.	2	4	Sprague.
Newburyport, Mass	Newburyport & Amesbury Horse Ry. Co	6	2	Thomson-Houston.
Newton, Mass	Newton Circuit Line	8	10	Thomson-Houston.
Newport, R. I	Newport St. Ry. Co	4.5	6	Thomson-Houston.
New York, N. Y.	North & East River Ry. Co.	3	20	Bentley-Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Omaha, Neb	Omaha & Co'ncil Bluffs R. R.	4	2	Sprague.
Ontario, Cal	Ontario & San Antonic Heights Ry. Co	8	4	Daft.
Ottawa, Ill	Ottawa Electric St. Ry. Co.	5	8	Thomson-Houston.
Ottumwa, O	Ottuma St. Ry. Co	5	4	Thomson-Houston.
Passaic, N. J	Passaic St. Ry	3	3	Thomson-Houston.
Peoria, Ill	Central Ry. Co	10	15	Thomson-Houston.
Pittsburgh, Pa	Federal Street & Pleasant Valley R. R	8½	25	Sprague.
Pittsburgh, Pa	Pittsburgh Suburban Rapid Transit Co		3	Daft.
Pittsburgh, Pa	Squirrel Hill R. R	3½	5	Sprague.
Plattsmouth, Neb	Plattsmouth Electric R. R.	2	2	Sprague.
Port Chester, N. Y	P. C. & Rye B'ch St. Ry. Co.	3	5	Daft.
Portland, Oregon	Metropolitan R. R	3	4	Sprague.
Portland, Ore	Willamette Bridge Co	1.5	5	Sprague.
Quincy, Mass	Quincy St. Ry	5	4	Thomson-Houston.
Redbank, N. J	Redbank & Seabright Ry	5	3	Thomson-Houston.
Richmond, Ind.	Richmond St. Ry. Co	4	6	Thomson-Houston.
Richmond, Va.	Richmond City Ry. Co	7.5	50	Sprague.
St. Joseph, Mo	People's R. R. Co	10	20	Sprague.
St. Louis, Mo	St. Louis Bridge Co	2	4	Thomson-Houston.
Sarat'ga Springs, N. Y.	Saratoga Electric Ry. Co	2	4	Thomson-Houston.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Electric Ry	6.75	6	Sprague.
Scranton, Pa	Hillside Coal Co	1	1	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Spokane Falls, W. T.	Ross Park St. Ry. Co	7.50	6	Thomson-Houston.
Springfield, Mo				Fisher.
St. Louis, Mo.	Lindell Ave. R. R	5½	10	Sprague.
Sterling, Ill	Union Electric R. R	6	7	Sprague.
Sunbury, Pa.	Sunbury & N'th'land Ry. Co.	3½	3	Thomson-Houston.
Tacoma, Wash. Ter	Pacific Ave. St. R. R.	6	6	Sprague.
Tacoma, Wash. Ter.	Tacoma Ave. St. Ry. Co	2	4	Sprague.
Toledo, O	Toledo Electric Ry. Co	2	2	Thomson-Houston.
Troy, N. Y	Troy & Lansingburg Street R. R.	5	6	Sprague.
Vancouvre, Island	Victoria Electric St. Ry. Co.	4	4	Thomson-Houston.
Washington, D. C	Georget'wn, Tenalley Town St. Ry. Co	3	6	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & West Side R. R.	4	3	Sprague.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.
West Bay City, Mich.	West Bay City Elec. Ry. Co.	5	8	Sprague.

Total—Roads 78

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

THE CONVENTION AT NIAGARA FALLS, AUGUST 6-8.

The final preparations for the Niagara Falls Convention, August 6, 7 and 8, have been completed. From the following partial programme it will be seen that the Convention will be of more than ordinary interest:—

The Convention will be welcomed to Niagara Falls by the Hon. W. C. Ely. President E. R. Weeks will open the Convention with an address, including among other things, a statistical account of the present state of the electric light and power industries. The executive committee will report through its chairman, Mr. Benjamin Rhodes, who will record the general work of the Association for the last six months, and more particularly that portion of it not fully covered in the other committee and official reports. This will be followed by the usual report of the secretary and treasurer.

The committee on harmonizing the electric light and insurance interests will report through its chairman, Mr. P. H. Alexander, who will present statistics on the fire losses collected and the insurance premiums paid by electric light companies; the committee will also recommend measures by which insurance rates on electric light stations may be lowered. The national committee on state and municipal legislation will report through its chairman, Mr. Allan R. Foote, of Cincinnati. The committee on the revision of the constitution will report through its chairman, Dr. Otto A. Moses, who will submit a carefully considered revision of the present constitution.

The following papers will be read:—

"The Value of Economic Data to the Electric Industry," by Mr. Allan R. Foote, of Cincinnati; "Electric Street Railways," by Mr. George W. Mansfield, of Boston; "An Ideal Station," a paper in two parts, from an Electrical Standpoint, by Mr. Marsden J. Perry, of Providence—From a Mechanical Standpoint, by Mr. John T. Henthorn, of the same city; "The Economic Size of Line Wire," by Benjamin Rhodes, of Niagara Falls; "Station Accessories in the Shape of Measuring Instruments," by C. C. Haskins, of Chicago; "The Development and Progress of the Storage Battery," by Mr. William Bracken, of New York; "The Theoretically Perfect Arc Light Station," by M. M. D. Law, of Philadelphia; "The Electrical Transmission of Power," by Professor E. P. Roberts, of Cleveland; Mr. A. J. De Camp will address the Convention on "The Methods of Arriving at the Cost of the Products of a Station."

PERSONAL MENTION.

MAJOR GEORGE A. HOWARD has been appointed agent of the Brush Electric Co., at Nashville, Tenn. Major Howard has established his office in the Young Men's Christian Association building.

GEORGE H. USHER, of the firm of Jones & Usher, of Buffalo, N. Y., has been appointed by the Board of Fire Underwriters their electrical expert.

Mr. H. Ward Leonard, president of the Leonard and Izard Co., of Chicago, recently arrived in New York, to assume his duties as general manager of the Edison United Manufacturing Co.

Mr. Maurice B. Flynn, the well-known politician and capitalist of New York, and who gave such an impetus to electric street railways by equipping the most important car line in Richmond, Virginia, with electric motors, is dead.

The Washington (D. C.) *Evening Star* pays a deserved tribute to electric motors in general and the "C. & C." motor in particular, for having been enabled thereby to continue the publication of their paper when a flood had rendered their engines useless. Three 15-h. p. "C. & C." motors were ordered by telegraph through Mr. C. W. Messner, local agent.

CAPTAIN WILLARD L. CANDEE, treasurer of the Okonite Co., of New York, returned from his European trip on the 4th instant. He succeeded, besides taking several smaller orders, in making a contract with the City of Paris, for 8,000 feet of okonite telephone and telegraph wire. Captain Candee examined many important locations in England, with a view of establishing a manufactory there, to supply the European demand for okonite wires and cables. The captain gives a glowing account of the American department of the Paris Exposition.

MR. W. M. YENAWINE, manager of the St. Joseph, Mo., Telephone Exchange, has received the appointment of assistant superintendent of the Missouri and Kansas Telephone Co. Mr. Yenawine began his business career as a lineman, and by reason of his devotion to his employer's interests has been promoted step by step. The selection is well deserved, and will bring credit to the management of the telephone company.

MR. F. B. TROUT, of Detroit, general manager of the Woodward Electrical Co., of that city, has resigned his official position in order to give attention to his private interests.

MANUFACTURING AND TRADE NOTES.

MR. C. S. VAN NUIS, who has installed several central stations for the Edison company in this vicinity, has opened an office at 18 Cortlandt street, New York, as a consulting and contracting electrical engineer.

THE P. and B. CONDUIT AND CONSTRUCTION CO., 59 Maiden lane, New York, has been organized as a branch of the business of the Standard Paint Co., the owners of the "P. and B." compounds. The Conduit company will devote itself to the underground conduit industry.

MESSRS. HAZAZER AND STANLEY, manufacturing electricians, New York, have taken into partnership Mr. Harry Hall, a young man who has been associated with the firm for some time past.

THE CENTRAL ELECTRIC CO., of Chicago, have issued a pamphlet containing an interesting article on arc lighting by C. C. Haskins, inspector of electric lighting for the City of Chicago.

THE contract for the two large duplex gas compressors and boilers for the Kentucky Rock Gas Co., was placed with the Clayton Air Compressor Works, No. 43 Dey street, New York.

These compressors have a capacity of 2,000,000 cubic feet per day, and are to compress the natural gas at the wells to a pressure of 200 pounds per square inch, and force it a distance of 32 miles to Louisville, for light and power purposes.

The Clayton air compressors are extremely well adapted for compressing natural gas, and they have been employed for this purpose with conspicuous success at the natural gas fields of Bradford and Wellsville.

MESSRS. E. E. GARVIN & CO., who recently removed to their new buildings at Laight and Canal streets, in addition to their general stock of machinery, have on sale a considerable assortment of second hand machinery, of various makes, including engine and hand lathes, drill presses, milling machines, planers, etc.

THE HILL CLUTCH WORKS, through their eastern manager, Walter C. Wonham, report that in addition to the recent shipments of power transmission machinery and "Hill" friction clutches to the Brush Electric Co., Buffalo, N. Y.; Salem Electric Light Co.; Fitchburg Gas Co., and the City of Bangor, Me., they have also made large shipments of their well-known specialties to the Belfast Electric Co., Belfast, Me.; Quincy Electric Light Co., Quincy, Mass.; Thomson-Houston Electric Co. for shipment to Bilboa, Spain; the Thomson-Houston Electric Light Co., Lyons, N. Y.; the State Hospital, Poughkeepsie, N. Y.; American Tool and Machine Co., Boston; Edison Machine Works, New York; Jos. Bancroft & Sons, Wilmington, Del. They further report that their trade continues good and that they are taxed to the utmost on orders from their regular customers to say nothing of new business which is coming in at a rapid rate.

THE BALDWIN LOCOMOTIVE WORKS are replacing two of their Buckeye engines with a Westinghouse compound engine of 100 h. p. This company has subdivided its power, and now has 11 Westinghouse engines, aggregating 854 h. p., in different parts of its extensive works. The Westinghouse company are also replacing a 100 h. p. Ball engine, at the Binghamton Electric Light Co., with a compound engine.

THE modern plan of subdividing steam power, in other words, the primary transmission of power from the boiler to the work by means of steam pipes in place of belts and shafting, is rapidly growing in favor. Westinghouse, Church, Kerr & Co. are leaders in this branch of engineering, and are now fitting up the plant of the Long Island Railroad at East New York, using in place of a single engine, three engines of 75, 60 and 25 h. p. respectively.

THE SAFETY LIGHT AND POWER CO. have commenced the erection of their extensive station in New York city. They will operate the Westinghouse alternating system, and have contracted for six Westinghouse compound engines, each of 150 h. p.

THE DENVER CONSOLIDATED ELECTRIC CO. have placed an order for two 200 h. p. Westinghouse automatic compound engines. Some four months ago, they contracted with Fairbanks & Co., of St. Louis, Mo. (agents for the Westinghouse Machine Co.), for a Westinghouse compound engine of 125 h. p., which engine, Fairbanks & Co. guaranteed would show a water consumption not to exceed 25 pounds per indicated horse-power per hour. The engine was duly shipped, and after being set up and run a short time, a test was made in order to ascertain the fuel economy. The test showed the water consumption to be less than 23 pounds per indicated horse-power per hour. On this showing, the Denver Consolidated Electric Co. awarded the contract for their additional steam power to Fairbanks & Co., for two 200 h. p. Westinghouse compound engines, as before stated.

MR. PHILIP DIEHL, the versatile inventor, of Elizabeth, N. J., has put upon the market a very practical and convenient electric fan. It is of the form that is often found attached to ceilings, the fan revolving horizontally. The electric motor, of Mr. Diehl's

well-known form, is neatly enclosed in the cast-iron support attached to the ceiling, its shaft extending downwards to the revolving fan. The apparatus is made for use on arc or incandescent lighting circuits.

MR. JARVIS B. EDSON has removed to 87 Liberty street, New York. Mr. Edson's new quarters will be better adapted to the needs of his increasing trade in recording gauges.

MESSRS. PARTRICK AND CARTER, of Philadelphia, have issued a large sheet containing illustrations of many of the various designs of their patent needle annunciators and burglar alarms, together with a list of hotels and public buildings supplied with annunciators and other goods of their manufacture. This firm's goods have been so long and favorably known to the trade, however, that the large list of patrons occasions no surprise.

C. UPHAM ELY, 35 Dey street, is introducing a new battery, called the "Brooklyn," for open circuit work. Mr. Ely informs us that the battery contains compounds never before used in a primary battery, and by means of which he claims to secure greater durability than is obtained with other cells.

THE HOLTZER AND CABOT ELECTRIC CO., of Boston, will hereafter control the sale of the secondary batteries and other apparatus of the Electrical Accumulator Co., of New York, for the states of Massachusetts, New Hampshire and Vermont.

NEW INCORPORATIONS.

Backstrom Electric Co., New York, Charles A. Backstrom and others. Capital, $50,000.

Bellaire Gas and Electric Co., Bellaire, O., W. Sinram and others. Capital, $150,000.

Centralia Electric Light and Power Co., Centralia, W. Ter., W. E. Partridge and others. Capital, $25,000.

Consumers' Electric Light and Power Co., Batavia, Ills. —— Capital, $25,000.

Darche Electric Co., Chicago, Ills., G. C. Darche and others. Capital, $100,000.

Gillham-Alexander Electric Manufacturing Co., Kansas City, Mo., Robert Gillham and others. Capital, $300,000.

Griggs Electric Air Signal Co., Wilmington, Del., A. C. Griggs and others. Capital, $100,000.

Harrodsburg Electric Light and Power Co., Harrodsburg, Ky., George Bohon and others. Capital, $25,000.

Illinois Anglo-American Storage Battery Co., Chicago, Ill., J. B. Long and others. Capital, $500,000.

Marble City Electric Light Co., Rutland, Vt., C. Parmenter and others. Capital, $50,000.

Miami Valley Electric Co., Dayton, O. Capital, $30,000.

Milwaukee Electric Light Co., Chicago, Ills., F. B. Uhrig and others. Capital, $100,000.

Pacific Writing Telegraph Co., San Francisco, Cal., M. L. Hadley and others. Capital, $2,500,000.

Pana Electric Light Co., Pana Ills., A. B. Corman and others. Capital, $60,000.

Seneca Electric Light and Power Co., Seneca, Kans., Milton B. Smyth and others. Capital, $30,000.

Sheboygan Electric Light Co., Sheboygan, Wis., A. F. Leberman and others. Capital. $25,000.

Southern Electric Light Co., Baltimore, Md., J. Frank Morrison and others. Capital, $100,000.

Southern Ohio Electric Service Co., Cincinnati, O. Capital, $25,000.

Thomson-Houston Electric Light and Power Co., St. Paul, Minn., H. W. Turner and others. Capital, $500,000.

Toledo Electric Street Railway Co., Toledo, O., O. S. Brumbock and others. Capital, $500,000.

Union Electric Co., Toledo, Ohio. Capital, $100,000.

Washington and Idaho Telegraph Co., Spokane Falls, W. T., John Stone and others. Capital, $50,000.

Argentine Water and Electric Co., Argentine, Kan., T. J. Enright and others. Capital, $150,000.

Chester Electric Light and Power Co., Chester, S. C., G. J. Paterson and others. Capital, $5,000.

Chicago Storage Battery Co., Chicago, Ills., Charles S. Raddin and others. Capital, $150,000.

Cook County Conduit Co., Chicago, Ills., David Sullivan and others. Capital, $25,000.

Electric Motor Renting Co., Chicago, Ills., D. Dichington and others. Capital, $30,000.

El Paso Gas and Electric Power Co., El Paso, Texas. Capital, $300,000.

Lakeside Light and Power Co., Lakeside, Minn., D. G. Cash and others. Capital, $50,000.

Lewistown Electric Light, Heat and Power Co., Lewistown, Ills., L. W. Rose and others. Capital, $10,000.

National Electric Traction Co., Detroit, Mich., W. A. Jackson and others. Capital, $100,000.

Norfolk Electric Co., Portland, Me., Melville P. Morrill and others. Capital $1,000,000.

Piqua Electric Light and Power Co., Piqua, O. —— Capital, $25,000.

San Pedro Electric Light and Power Co., San Pedro., Cal., E. E. Peck and others. Capital, $100,000.

Sheboygan Electric Light Co., Sheboygan, Wis., A. F. Leberman and others. Capital, $25,000.

Standard Electrical Subway Co., New York, John J. Wilson and others. Capital, $250,000.

LEGAL NOTES.

THE FAURE ACCUMULATOR PATENTS.

Judge Coxe in the United States Circuit Court for the Southern District of New York, rendered a decision on July 22, reaffirming his former judgment in favor of the Electrical Accumulator Co. in its suit against the Julien Electric Co., to establish the validity of the Faure secondary battery patent, and denying the Julien company's motion for a rehearing.

The Julien company in its argument claimed among other things, that it could manufacture by the "dry powder" process, batteries as good or better than it was possible to manufacture under the Faure process by the use of a "paste," and in this connection Judge Coxe says:—

"If it be true that Faure's batteries are inferior to or no better than others, the question naturally suggests itself—Why are not defendants content to use other batteries? A rehearing is denied."

According to the views of the Electrical Accumulator Co., this gives the complete control of the manufacture and use of secondary batteries to that company, which owns the Faure-Sellon-Volckmar patents.

FINAL DECISION AGAINST THE CUSHMAN COMPANY.

A final deccree was rendered July 24, by Judge Blodgett in the Federal Court at Chicago, in the long-pending litigation between the Bell and Cushman telephone companies. The Bell company brought two suits against the Cushman company for infringement of patent. The decree in both suits is against the Cushman company. A fine of $1 is assessed against it, and it is ordered to turn over all of its telephones to the Bell company.

MISCELLANEOUS.

UP to the time of going to press nothing has been heard of the expected decisions in the suit of the Consolidated Electric Light Co. against the McKeesport Light Co., which was heard before Justices Bradley and McKennan at Pittsburgh last May, nor in the suit of the Edison against the Westinghouse company on the three-wire patent for electrical distribution, which was heard at Trenton before Judge McKennan a few days earlier.

THE pending suit of the Edison company against the local Thomson-Houston company at New Haven, alleging infringement of the three-wire patent, is progressing slowly, both parties being apparently disposed to await the result of the Trenton case, above referred to.

IMMEDIATELY after the issue of the Weston patent for the construction of armatures of insulated sections, a test suit was commenced by the United States Electric Lighting Co. against the Manhattan Electric Light Co., of New York, using the Thomson-Houston apparatus.

THE Westinghouse Electric Co. also instituted proceedings upon the Rankin Kennedy patent for alternate current distribution in multiple arc, within two or three days after its issue. The suit has been brought against the recently established local electric lighting company at Bedford, Pa., which uses the Thomson-Houston system. It is intended, we understand, to press this suit to final hearing as soon as possible.

THE Sprague Electric Railway and Motor Co. have brought suit in Massachusetts against the Thomson-Houston Electric Co., alleging infringement of Sprague's patent, No. 324,892, for a spring motor suspension, and will soon commence taking evidence in the case. It is understood that the Sprague company are preparing to bring several more suits, not only against the Thomson-Houston but against other competitors in the electric railway business.

IN the suit of the Western Electric Co. against the New Haven Clock Co., for infringement of L. B. Firman's patent for a multiple-call district signal box, considerable amount of evidence has been taken, and we understand that the case is nearly ready to be closed.

IT is reported that a proposition has been made to submit to arbitration the claim of the Western Union Telegraph Co. against the Postal Telegraph and Cable Co. for infringement of certain patents relating to quadruplex telegraphy.

INVENTORS' RECORD.

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From June 18, to July 16, 1889 (inclusive).

Alarms and Signals:—*Electric Bell-Pull*, C. A. Braun, 405,525. *Thermostat*, J. H. Mallon, 405,579, June 18. *Electric Signaling System*, M. W. Dewey, 405,831, June 25. *Electric Signaling Device*, J. C. O'Neil, 406,057. *Annunciator*, A. A. Vanderpool, 406,277. *Combined Electric Bell and Annunciator*, J. F. McLaughlin, 406,293. *Electric Trembler Bell*, same, 406,294, July 2. *Signaling Apparatus for Elevators*, J. F. Bower, 406,423. *Invisible Burglar-Alarm Electric Mat*, J. W. Dawson, 406,709. *Signal or Alarm Transmitter and Time-Indicator*, A. J. Reams, 406,769, July 9. *Signaling Apparatus*, G. F. Milliken, 407,101, July 16.

Conductors, Insulators and Conduits:—*Pilot or Head for Sectional Rods for Threading Underground Conduits*, G. H. Warde, 405,515. *Insulator*, R. P. Frist, 405,546. *Electric Wire Conduit*, J. Lynch, 405,576, June 18. *Insulator for Electric Wires*, J. C. Gill, 406,041. *Insulated Electric Wire*, H. W. Johns, Jr., 406,284. *Telegraph Pole*, C. M. Russell, 406,406, July 2. *Underground Conduit for Electrical Conductors*, G. W. Cook, 406,818, July 9. *Non-Conductive and Elastic Waterproof Composition for Pipe-Joints, &c.*, B. Overlack, 406,949. *Underground Conduit*, T. Wallace, 406,978, July 16.

Distribution:—*Method of Electrical Power Transmission*, N. Tesla, 405,859, June 25. *Automatic Regulation of Electrical Circuits*, W. W. Griscom, 407,-006. *System of Electrical Distribution*, D. Higham, 407,204. *Method of Electrical Distribution by Secondary Generators*, R. Kennedy, 407,294, July 16.

Dynamos and Motors:—*Compound-Wound Alternating Current Dynamo*, H. Lemp, 405,263. *Dynamo-Electric Machine*, F. Thone, 405,284. *Dynamo*, E. A. Sperry, 405,441. *Dynamo-Electric Machine*, W. D. Sandwell, 405,507. *Dynamo-Electric Machine or Motor*, C. L. Rosenquist, 405,602. *Electric Motor or Dynamo-Electric Machine*, R. M. Hunter, 405,663, June 18. *Regulator for Dynamo-Electric Machines*, J. H. Robertson, 405,743. *Electro-Magnetic Motor*, N. Tesla, 405,858. *Dynamo-Electric Machine* T. L. Willson, 406,015, June 25. *Dynamo*, W. S. Andrews and T. Spencer, 406,415. *Dynamo Armature*, S. C. C. Currie, 406,429. *Armature Winding for Dynamos*, J. J. Wood, 406,492. *Self-Regulating Dynamo*, same, 406,493. *Regulator for Dynamo-Electric Machines*, same, 406,494. *Dynamo-Electric Machine*, W. L. Silvey, 406,599. *Armature for Electric Machines*, A. Schmid, 406,777, July 9. *Electric Motor*, J. Buckley, 406,874. *Electric Motor*, G. W. Mansfield, 406,922. *Dynamo-Electric Machine*, N. Tesla, 406,968. *Regulator for Electric Motors*, J. F. Kelly and P. H. Brangs, 407,014. *Commutator Brush and Holder*, O. P. Loomis, 407,225. *Electric Motor*, L. G. Woolley, 407,272. *Regulation of Electric Motors*, D. Higham, 407,293, July 16.

Galvanic Batteries:—*Galvanic Battery*, W. A. Childs, 405,216; J. Serson, 405,609, June 18. *Electric Battery*, C. A. Hussey, 406,168 and 406,169. *Galvanic Battery*, J. E. Lee, 406,223, July 2; M. Dougans, 406,636; F. Lotz, 406,-656; H. Groswith, 406,726, July 9; P. B. Delany, 406,997, July 16.

Lamps and Appurtenances:—*Sheath for Regulating Light from Electric Lamps*, W. H. Melaney, 405,427. *Electric Arc Lamp*, E. A. Sperry, 405,410. *Manufacture of Carbon Filaments*, T. V. Hughes and C. R. Chambers, 405,-480, June 18. *Electric Lighting System*, H. W. Leonard, 405,896. *Electric Arc Lamp*, H. Pieper, Fils., 405,906. *Adjustable Support for Incandescent Electric Lights*, J. T. Pearson, 405,970, June 25. *Manufacture of Incandescent Electric Lamps*, T. A. Edison, 406,130, July 2. *Incandescent Lamp*, C. A. Backstrom, 406,498, July 9. *Lighting System*, J. H. Hunter, 407,210, July 16.

Measurement:—*Electric Meter*, O. Dahl, 405,249; R. & P. Diehl, 405,399, June 18; E. Thomson, 406,010, June 25. *Recording Apparatus for Electric Meters*, G. W. Walker, 406,678. *Electric Meter*, T. A. Edison, 406,824 and 406,825, July 9.

Medical and Surgical:—*Electro-Medical Belt*, W. J. Shelton, 405,436, June 18. *Electrode for Therapeutic Body-Wear*, H. P. Pratt, 406,306, July 2. *Electro-Therapeutic Device*, same, 407,116, July 16.

Metallurgical:—*Magnetic Separator*, G. Conkling, 406,337, July 2, and re-issue, 11,012, July 16.

Metal Working:—*Process of Electric Welding*, C. L. Coffin, 405,345, June 18.

Miscellaneous:—*Electric Switch*, O. Dahl, 405,248. *Friction Generator*, H. E. Waite, 405,334. *Apparatus for the Electrolysis of Lead*, C. O. Yale, 405,452. *Apparatus for Generating Electricity*, T. Gleeson, 405,471. *Ground-Detector for Electric Circuits*, O. P. Loomis, 405,572. *Machine for Blackleading the Molds for Electrotypes*, W. Miles, 405,585. *Production of Copper by Electrolysis*, A. Rovello, 405,604. *Electrical Primer*, E. L. Zalinski and H. J. Smith, 405,646; H. J. Smith and E. L. Zalinski, 405,684, June 18. *Electrolier*, J. M. Orford, 405,742, June 25. *Electric Registering Apparatus*, J. A. Lannert, 406,172. *Device for Automatically Manipulating the Valves of High Vacuum Pumps*, E. B. Nicolaus, 406,231. *Cut Out*, S. C. C. Currie, 406,268. *Electrical Type-Writing Machine*, J. F. McLaughlin, 406,291. *Type-Writing Machine*, same, 406,292. *Electric Coupling and Circuit-Closer*, W. H. Baker, 406,331. *Electrical Fire Extinguisher*, T. R. Douse, 406,341. *Anti-Magnetic Watch*, C. T. Mason, 406,364. *Electrical Type-Writer*, M. W. Dewey, 406,390, July 2. *Pneumatic Switch for Pneumatic Dispatch-Tubes*, P. Kennedy, Jr., 406,446. *Electrical Switch*, J. A. Powers, 406,468. *Connection-Box*, same, 406,469. *Silk-Reeling Machinery*, E. W. Serrell, 406,598. *Electric Horse-Disconnector*, G. A. Coulter, 406,629. *Lightning Rods*, J. H. C. Watts, 406,681. *Electrical Apparatus for Regulating Steam Boilers, &c.*, F. Martenot, 406,-751. *Laminated Core for Electrical Apparatus*, A. Schmid, 406,776. *Message and Time Recorder*, J. C. Wilson, 406,809. *Method of Forming Laminated Cores for Electrical Apparatus*, A. Schmid, 406,858. *Method of Forming Cores for Electrical Apparatus*, same, 406,859, July 9. *Electric Switch*, T. F. Gaynor, 406,897. *Cut-Out for Electric Circuits*, W. S. Hill, 406,906. *Electric Wiring*, F. R. Chinnock, 406,994. *Electric Cut-Out*, J. L. Kimball and H. C. Wirt, 407,077. *Electric Brush*, H. P. Pratt, 407,115. *Electric Machine*, E. H. Bennett, Jr., 407,154, July 16.

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H. P. BROWN, "ELECTRICAL ENGINEER."

"MASTERS, it is proved already that you are little better than false knaves, and it will go near to be thought so shortly." The immortal Dogberry's topsy-turvey but unconsciously accurate remark to his prisoners is somewhat apt to the present situation of Mr. Harold P. Brown. The humbug of his posing as a philanthropist in his officious efforts to further the operation of the electrical execution law in this state and his obvious intention to bring discredit upon the electric lighting machinery of a particular company were sufficient proof, months ago, to the minds of all well-informed electricians and people acquainted with Brown's business and professional standing, that some motive more substantial than a tender regard for the sufferings of criminals lay beneath his activity in furthering the plans of the misguided though well-meaning gentlemen to whom we owe the odium of the obnoxious law; "and it will go near to be thought so shortly" by the general public of the state, in view of the publication in the New York *Sun*, August 25, of a series of remarkable letters between Brown and several individuals and corporations who have been aiding him in his undertakings. The letters are 45 in number, and consist of correspondence between Brown on the one hand, and the Edison Electric Light Co., agents and employés of that company, Thomas A. Edison, the Thomson-Houston Electric Co., the Edison United Manufacturing Co., F. Ridlon & Co., Boston (dealers in second-hand electrical machinery), and several individuals on the other hand.

The letters show that Brown's chief object was to bring the alternating current lighting machinery of the Westinghouse company into disrepute by securing the adoption of it by the state for use in electrical executions, and that he has been assisted in furthering that object by rivals of the Westinghouse company. It appears from the letters that the Thomson-Houston company and Messrs. Frank Ridlon & Co. took a hand in securing for Brown the second-hand Westinghouse dynamos obtained for the state prisons. April 23, Brown writes to the Thomson-Houston company:—

> I shall want for New York state, and am authorized to purchase same, three 650-lighters, with exciter and rheostat; two of these they want immediately, and they allow me to use the third for the Baltimore test. *Of course your company's connection with the matter has not been and will not be mentioned by me.*

In reply, the Thomson-Houston company wrote that they "could probably secure apparatus in a short time," and they seem, with the aid of Mr. Ridlon—who appears to have been somewhat mystified by the proceedings at first—to have followed the business up with due diligence, picking up the three second-hand Westinghouse machines, one after another, for Mr. Brown. The reference to the "Baltimore test" in the above extract refers to a trial of the Westinghouse machine at Johns Hopkins University laboratory, that Brown had, it seems, been trying to bring about in connection with the Thomson-Houston company and on account of which that company agreed to pay him $1,000, which sum, it appears, they did pay him July 10, although, apparently, the tests have not yet been made.

The Thomson-Houston people, after a while, seem to have had some doubts of the adequacy of the Westinghouse dynamo for Brown's job, and on May 22, wrote him:

> * * * We do not consider 1,000 volts alternating necessarily fatal to human life, and our opinion is that this current cannot be relied upon under all circumstances to immediately kill any man or animal, * * * it seems to us that a higher voltage should be applied by the authorities.

July 4, Brown, having become uneasy on account of the delay in getting the third machine, and expressing his fears that a decision against the constitutionality of the electrical execution law might result in the Kemmler case, and the whole electrical outfit, not yet paid for by the state, be left on his hands, said in a letter to Mr. Ridlon:—

> I have withstood tempting pressure and tempting offers to use other machines for that purpose, *but have nevertheless kept my agreement to the letter.*

Brown attempted to get funds for his scheme out of Mr. Edison. March 27, he wrote to "My Dear Mr. Edison," asking for $5,000, to enable him to buy three Westinghouse outfits for the state and to have tests made at Johns Hopkins University, and in this letter he said:—

> * * * *It will be done apparently by the T.-H. company.* * * * Do you not think that it is worth doing, as it will enable me through the Board of Health, to shut off the overhead alternating current circuits in the state, and will, by showing the lack of efficiency of the Westinghouse apparatus, *head off investors and prick the bubble,* thus helping all legitimate electrical enterprises?

The *Sun's* collection of letters contains no answer to this, and it may charitably, and it is to be hoped, justifiably, be believed that Mr. Edison contented himself with having given Brown a "testimonial signed by myself" five days earlier and kept his $5,000 in his pocket.

The letters throw a light on Brown and his doings that makes him look too much like a *chevalier d'industrie;* and his correspondents cannot be said to cut a very enviable figure.

In connection with the testimony recently taken in the

Kemmler case, the publication of Brown's correspondence constitutes a sorry outcome of the benevolent efforts of Mr. Elbridge T. Gerry and the Medico-Legal Society to provide "the most humane and practical method known to modern science of carrying into effect the sentence of death in capital cases."

THE ELECTRIC LIGHT CONVENTION.

THE FRACAS AT NIAGARA.

THE semi-annual meeting of the National Electric Light Association at Niagara Falls, August 6–8,—of which we print an abstract of the proceedings elsewhere in this issue—might be regarded as one of the most useful and encouraging conventions of that association since its organization but for the unfortunate misunderstanding that arose on the last day touching the adoption of the new constitution reported by the revision committee. The papers read and discussed were, for the most part, of a practical character, bearing upon topics of immediate interest to an association of men engaged in supplying electric light and power in the hope of making money out of them, and the measures adopted by resolutions and the appointment of special committees evinced a long look ahead and an adequate conception of the relations of electric light and power interests to the general business interests of the country. This is particularly true of the appointment of a committee to memorialize Congress for the abolition of the customs duty on copper, and of the effective support given to Mr. Allen R. Foote's measure for securing economic data from central stations in a systematic and uniform manner. It is safe to say, however, that after the sudden adjournment of the convention at noon of the last day the minds of all the delegates on the ground were more occupied by the summary enforcement of the new constitution, disfranchising the supply men and others coming under the class of associate members, than by the general work of the association. The agitation caused by the unfortunate affair has not yet subsided. We print elsewhere a letter from Mr. Weeks, dated August 16, some editorial comment thereon from the *Electrical Review* of August 25, and a later open letter from Mr. Weeks, reviewing the controversy from his point of view.

The majority of the supply men and others, classed now as associate members, felt injured, and many still feel so, by President Weeks's ruling, on the vote for next place of meeting, that the previous vote accepting the new constitution as reported by the revision committee had the effect of disfranchising at once all members except central station men. It has also been contended that the acceptance of the committee's report did not constitute an adoption of the new constitution. On the latter point little need be said. Those who invoke parliamentary law should know something about it. Mr. C. A. Brown, who moved "to accept" the report of the committee, had, in a communication to THE ELECTRICAL ENGINEER, printed in March number, 1889, page 153, under the caption "Out of Order," referring to some looseness of practice at the Chicago convention, quoted the following simple rule from Roberts's Rules of Order :—

> When the assembly is to consider a report, a motion should be made, to "adopt," "accept," or "agree to" the report, all of which, when carried, have the same effect, namely, to make the doings of the committee become the acts of the assembly, the same as if done by the assembly without the intervention of a committee.

At the Niagara meeting Mr. Brown took pains, before the vote, to correct the president, who had used the word "received" instead of "accepted" in stating the motion, whereupon the president restated it correctly. Parliamentary law should never take the place of fair play, at least never in a voluntary association ; but in this instance there was both parliamentary law and fair play. There was no excuse for any member's failure to understand the significance of the motion.

But we are unable to regard as fair play the enforcement of the new constitution to disfranchise members till the end of the fiscal year of the association. From the composition of the revision committee, the general approval by all classes of members of the changes proposed, through correspondence with the committee, and from many expressions of opinion by supply men and others, it is quite clear that no considerable objection existed to the proposed change in the status of members. It was, however, felt by such members as would lose their privilege of voting, that the new constitution could not properly abridge their rights until the expiration of the calendar year—up to which time dues are paid. This view was energetically reinforced by Mr. Morrison, to whose parliamentary knowledge and skill a large portion of the association has been accustomed to look for guidance in difficulties, and by President Weeks. Mr. Morrison said, when the report was presented on Thursday :—

> * * * but there is one point you have not considered. There is no constitution that you can pass now that will be operative until after the expiration of the fiscal year.

Following Mr. Morrison, Mr. Weeks said :—

> We certainly could not legislate members out of the association.

In his open letter to the members of the association (see page 417) Mr. Weeks, in defending his ruling of Thursday, disfranchising there and then all but central station men, says in substance, that the meaning of his remark of Tuesday, above quoted, was that the *central station men* could not legislate other members out of the association as voters. No one acquainted with Mr. Weeks will question his sincerity in any utterance whatsoever ; but we feel quite sure that no such limited construction of his words, and of Mr. Morrison's still more energetic expressions, on Tuesday, was thought of by the members who voted to accept the new constitution. We believe that nearly all, if not all, who so voted supposed, as a matter of course, that the existing rights of members would remain intact until January 1, 1890, and that they were confirmed and justified in this supposition by the words of the president and of Mr. Morrison. Moreover, to take up Mr. Weeks's contention, it does not appear, admitting that the vote adopting the new constitution was mainly given by non-central station men, that a majority of members of that class could more equitably legislate a minority of their class out of their rights than could a vote of central station men. Whatever the legal and technical effect of the vote on the committee's report may be as to the status and

rights of members who have paid their dues to the end of the fiscal year, we cannot call it fair play, in view of what occurred on Tuesday, to enforce the new rules of membership summarily against non-central station men, particularly on the occasion of an adverse vote upon a measure earnestly favored by the president and by Mr. Morrison.

Further; it seems to us probable that the difficulty would have been successfully and satisfactorily got over, but for the high-handed conduct of Mr. Morrison in bringing about a sudden and final adjournment of the convention. Mr. Morrison was called to the chair by the president to put the question on the appeal from the president's ruling, and for no other purpose, as we understand. Arming himself with the gavel, he not only declared the appeal out of order, but, after a hasty and ineffectual inquiry of the secretary—who seemed temporarily bereft of memory and reason—for further business, solicited a motion to adjourn, which was made and carried, and with a thump of the mallet declared the convention adjourned *sine die*. The collapse of the president and secretary under the strenuous insistance of Mr. Morrison was scarcely less pathetic than comical.

The moral, if there be one in all this, Mr. President and Gentlemen, seems to be something like this: Innocence and good intentions are not always enough. Learn the rules of the game you undertake to play. Play fair and with all your might, and it will be only your misfortune, not your fault, if stronger players get the better of you.

THE Referee's report in the Kemmler case will not appear till late in September, because of delay in printing. The evidence, drawings, exhibits, etc. will, it is said, fill two volumes of 600 pages each. A special despatch of August 27, from Buffalo to *The Evening Post*, states that "Brown's work on Electricity, a book of some size, was admitted as evidence." Copies of the report will be in demand as curiosities for electrical libraries, and it is to be hoped that a liberal edition will be struck off while the type is up.

COMMENTING upon the action of the Electric Light Association touching the customs duty on copper, *The Evening Post*, always to the fore in support of revenue reform, said in an editorial of August 20:—

> The resolution adopted unanimously by the Electrical Convention at Niagara Falls that the duties on copper ought to be repealed, and the appointment of a committee to prepare and circulate a petition to Congress for that purpose, constitute a very important movement towards the emancipation of industry. * *
> There never was any reason for putting a duty on copper or copper ore, except to promote a speculation in mining stocks and to enable the owners of mines to hold the price of American copper at a higher figure than the price of their own copper in foreign markets. * * *
> The only effect of such a duty is to enable the producers to form a combination against the consumers, and this has been done repeatedly. * * *
> If the electricians will go to work systematically, and circulate their petition thoroughly among their producers, employés and customers, they can secure the repeal of the copper tariff this winter. Public opinion, even in protectionist circles, was never much in favor of a duty on copper.

OBSERVATIONS.

BY T. D. LOCKWOOD.

THE idea of electrical resistance has grown familiar to us as A, B, C. We express the electrical properties of a wire or other conductor in ohms, a unit of resistance.

But it is after all rather anomalous, that we should even think of measuring the resistance or opposite or reciprocal of a conductor. Because a conducting wire has no resistance; or in other words what we call its resistance has no actual existence of itself, nor is any such quantity apparent until we undertake to pass electricity through the said wire. Therefore resistance, so far as we can properly conceive of it at all, must be conceived as a joint function of the electricity and the wire it traverses, certainly not of the wire alone.

For how can we, for instance, speak of a pipe adapted to carry water, as a pipe of so much friction or mechanical resistance. We never undertake to do this. But we do speak of it as a pipe of a certain capacity. The friction does not exist until the water flows. And in like manner it would seem that we might more properly speak of any conductor as being of a certain conductivity, instead of designating it by units of resistance.

Conductivity is indeed a function of the conductor; while resistance, non-existant until a current is passed through the conductor, is simply the relation between the applied E. M. F. and the conductivity, and is, therefore, more nearly a function of the electricity than of the conductor.

Though the idea of resistance as a quality of the conductor is well-rooted in the electrical mind, and will not be easy to dislodge, it may be predicted that it will be superseded; and that within the next 25 years.

* * *

A WRITER in *Forest and Stream*, proposes to depopulate sparrowdom by arranging uninsulated electrical wires in the late fall or spring, near the favorite breeding places of the English sparrow, and it is assumed that the undesirable bird will roost on the supposed death-dealing wire, and forthwith fall a victim. This writer has clearly never properly considered the question of "How many ohms will kill." I suppose that the sparrow forming a shunt for a length of wire equal to the length of his little stride, might theoretically receive (in view of his temporary fulfillment of the functions of a derived circuit) a trace of electricity; but I should be disposed to doubt that there would be much difference between the joint conductivity of the sparrow and the length of wire between his feet, and that of the said length of wire without regard to the sparrow.

* * *

"THE world do move." Eighteen months ago, I stood almost alone in opposing what was then a proposed law for the state of New York, the execution of capital punishment sentences by electricity.

I wrote a paper entitled "Electrical Killing," which was published in the ELECTRICAL ENGINEER of March, 1888, in which some of the arguments lately canvassed as possessing considerable weight are to be found. But in so far as that article received notice from our profession at all it was criticised adversely. But the world has moved, and electricians (all except a few who for occult reasons seem to wish to be handed down to posterity as Lord High Executioners) concur in the inadvisability of putting electricity and its votaries to such dirty work.

It may be that the objection that electricity will be degraded by such an application is a sentimental one; but the view which has now been put forward, that the use of electricity for deliberate killing will tend to excite an unreasoning and unreasonable fear of that force; and that this fear besides producing unnecessary mental suffering in many, will retard the progress of our profession and of the force with which we deal, cannot be regarded except as a most practical one. In the article to which I have referred, I wrote "Shall we indeed have a trade in execution supplies; and following the lead of the older crafts: the United States Electrical Execution Association; the American Institute of Electrical Executioners; the Old Timers' Association of Electrical Capital Punishment," etc.—One of these questions is already answered in the affirmative, and we already have the American Executing Co., of Chicago. Who'll be the next?

ARTICLES.

REVIEW OF THEORIES OF ELECTRICAL ACTION.[1]

BY PROFESSOR H. S. CARHART.

THE physics section of this association congratulates itself because it deals with topics of the most lively and general interest, not only from a practical point of view, but still more from a theoretical one. Even popular interest in electricity is now well nigh universal. Its applications increase with such prodigious rapidity that only experts can keep pace with them. At the same time the developments in pure electrical theory are such as to astound the intelligent layman and to inflame the imagination of the most profound philosopher.

Of the practical applications of electricity it is not necessary to speak. They bear witness of themselves. A million electric lamps nightly make more splendid the lustrous name of Faraday; a million messages daily over land and under sea serve to emphasize the value of Joseph Henry's contribution to modern civilization. Blot out these two names alone from the galaxy of stars that shine in the physical firmament, take from the world the benefits of their investigations, and the civilization of the present would become impossible. The value of the purely scientific work of such men is attested by the resulting well-being, comfort, and happiness of mankind.

But the mind can never rest satisfied with the facts and applications of a science, however interesting and useful they may be. It feels an inward impulse to link the facts into a related whole, to inquire into their causes, to frame a satisfactory theory of their correlation, and so to build on them a true science. It is, indeed, interesting to study the history of any scientific doctrine and to trace its development from the crude notions of its earliest stages to the more refined conceptions of later periods, comporting indefinitely better with the marvelous processes of nature. Such a history we have in the views which have been held regarding the nature and action of electricity. The transition from the glutinous effluvium of the sagacious Robert Boyle to the magnetic and electric waves of the present, traversing the omnipresent ether with the velocity of light, is not an easy one to make, even in a period of two hundred years. For more than twenty centuries natural philosophers had nothing better than the emission theory to account for the attraction exhibited by rubbed amber and other similar substances. Their notion was that the rubbing of the amber caused it to emit an effluvium which returned again to its source and carried light bodies back with it.

In one respect this fanciful attempt to explain electrical attraction deserves commendation, for it evinces a mental inaptitude to account for physical actions "at a distance," or without some intermediate agency. Later philosophers, satisfied perhaps too easily with mathematical explanations founded on the observed laws of attraction and repulsion, and not demanding a medium, did not feel the same intellectual necessity of filling the space between bodies acting on one another, either with emanations from those bodies or with an invisible, imponderable medium, suspected by no sense of man, but required only to meet a demand of his highest intelligence. For when the Newtonian philosophy had made some progress the doctrine of unctuous effluvia was given up, and physicists acquiesced in the unexplained principle of attraction and repulsion as properties of certain bodies communicated to them by the Divine Being, the mechanism of which they scarcely attempted to explain. "Many superficial philosophers thought they had given a very good account of electricity, cohesion and magnetism by calling them particular species of attraction peculiar to certain bodies."[2]

The discovery by Stephen Grey that "the electric virtue" could be conveyed along a wire for several hundred feet without sensible diminution, and the invention of the Leyden jar by Kleist, or Cuneus, had the effect of annihilating many mushroom theories constructed on the slimmest basis of facts. The latter discovery disclosed a power in electricity not previously suspected, and excited the greatest interest in both Europe and America. At this period Franklin turned his attention to the subject, and "spent more time in diversifying facts and less in refining upon theory" than some of his European contemporaries. In fact, he tells us that he was never before engaged in any study that so totally engrossed his attention and his time. His discovery that the two electricities are always excited in equal quantities, that the charge resides on the glass and not on the coatings of the Leyden jar, and his experimental identification of lightning with frictional electricity excited the liveliest interest abroad, and secured for him the Copley medal of the Royal Society; while his theory of positive and negative electricity made a permanent addition to the nomenclature of the science. His conceit that a turkey, killed with the discharge of a battery of jars, was uncommonly tender eating, a discovery gravely communicated to the Royal Society by William Watson, is not so well-known, and does not appear up to the present to have been verified.

We cannot agree with him, I am sure, when he says: "Nor is it of much importance for us to know the manner in which Nature executes her laws; it is enough if we know the laws themselves." For the pursuit of the manner in which Nature executes her laws is the distinguishing characteristic of the science of the present day. It has led to most brilliant discoveries, and bids fair to do more than all other agencies combined to show the intimate and necessary relations existing between the different branches of physics. We need to be reminded often that accumulated facts do not constitute a science; and that utility is not the highest reward of scientific pursuits. A bit of polished marble plucked from the ruins of the Roman Palatine Hill is an interesting relic; but how much more interesting to reconstruct the palace of Nero and to see this fluted marble in its proper and designed relation to the whole, of which it was once a necessary part! Science is constructive. Laws are derived from an attentive consideration of facts; generalizations group laws under broader relationships; and great principles unite all together into one related, impressive whole.

From the time when the famous Boyle caught sight of a faint glimmer of electric light to the present, physicists have been in pursuit of the connection between light and electricity. As early as Newton's time, the ether was conceived by some to be a subtle medium confined to very small distances from the surfaces of bodies, and to be the chief agent in all electrical phenomena. "But," says Priestley,[3] "the far greater number of philosophers suppose, and with the greatest probability, that there is a fluid, *sui generis* principally concerned in the business of electricity., They seem, however, though perhaps without reason, entirely to overlook Sir Isaac Newton's ether; or if they do not suppose it to be wholly unconcerned, they allow it only a secondary and subordinate part to act in this drama." Among the branches of knowledge that this writer recommends as likely to be of especial service in the study of electricity is the doctrine of light and colors. The invention of the voltaic battery, and Sir Humphrey Davy's celebrated experiment in producing the electric arc stimulated inquiry in this same direction. Mrs. Somerville, Morrichini, and others, sought to produce magnetism by means of sunlight, but ultimately, as is now known, without success. Notwithstanding these negative results, Faraday had such a "strong persuasion derived from philosophical

1. Address by Professor Carhart, Vice-President Sec. B, American Association for the Advancement of Science, delivered at the annual meeting, Toronto, August 28, 1889.

2. Priestley's Hist. of Elec., vol. ii., p. 18.
3. Hist. of Elec, vol. ii., p. 22.

considerations" of a direct relation between light and electricity that he resumed the inquiry in a most searching manner, with the happy result of discovering the rotation of the plane of polarization of light by means of magnetism. "Thus is established," he says,[4] "a true, direct relation and dependence between light and the magnetic and electric forces; and thus a great addition [is] made to the facts and considerations which tend to prove that all natural forces are tied together, and have one common origin."

It was thus reserved for Faraday to make those discoveries and to obtain that insight into electric and magnetic action which were needed by his great disciple and interpreter, Maxwell, to construct a most marvelous theory of the connection between these two departments of physical science.

Respecting the failures to obtain magnetism from the direct action of sunlight, to which allusion has been made, Maxwell says that we should not expect a different result because the distinction between magnetic north and south is one of direction merely; that there is nothing in magnetism indicating such opposition of properties as is seen at the positive and negative poles of a battery in electrolysis; that even right and left-handed circularly polarized light cannot be considered the analogue of the two poles of a magnet, for the two polarized rays when combined do not neutralize each other but produce plane polarized light.

It may be said, however, that if a right-handed circularly polarized ray produces magnetism in one direction, and a left-handed ray in the opposite, then the combination of the two rays may neutralize their magnetic effect inasmuch as plane polarized light may have no magnetic influence. Professor J. J. Thomson has lately shown mathematically that a circularly polarized ray does have a magnetic effect, but that it is so small, even with strong sunlight, as to be much beyond the limits of experiment; and Mr. Shelford Bidwell has produced a bar of iron in such an exquisitely sensitive magnetic state that magnetic changes are certainly produced in it by the direct action of light. This he has secured by rendering the bar more susceptible to magnetic influences in one direction than the other. We may not, I venture to affirm, be without hope that magnetism and electric currents may yet be evoked by the direct agency of sunlight.

Faraday was deeply convinced that space had magnetic properties, and that the space or medium around a magnet is as essential as the magnet itself, being a part of the complete magnetic system. To him all magnetic and electric action took place by contiguous particles along lines of force. "What that magnetic medium, deprived of all material substance, may be, I cannot tell," he says,[5] "perhaps the ether." No doubt existed in Faraday's mind that these lines represent a state of tension; but whether that tension is a *static* state in the ether, or whether it is *dynamic*, resembling the lines of flow of a current between the poles of a battery immersed in a conducting fluid, was uncertain. He inclined, however, to the latter view. He was thus led to advocate, though not without hesitation, the physical nature of lines of force.

Faraday's discoveries and his method of regarding all magnetic and electric actions as propagated through a medium by means of contiguous parts have been of the utmost productiveness. They have revolutionized the science of electricity, and have been the most potent factors in the genesis of a theory, including all radiant energy, which has recently received such remarkable and conclusive confirmation. His name has become almost a household word. His earnest, unselfish life has added unnumbered millions to the world's wealth. His ideas and words, which have been instruments in the hands of philosophers, have become the current coin of the commercial tyro, who talks as glibly about lines of force and the magnetic circuit as if he really knew something about them.

Fruitful as Faraday's ideas were they yet awaited a mathematical interpreter for their highest development. A good Providence sent James Clerk Maxwell, whose brilliant mathematical ability was equaled by his philosophic insight, his poetic feeling and imagination, his profound sincerity and his great sympathy with nature. Here him sing at Aberdeen:—

"Alone on a hillside of heather,
  I lay with dark thoughts in my mind,
In the midst of the beautiful weather,
  I was deaf, I was dumb, I was blind,
I knew not the glories around me,
  I counted the world as it seems,
Till a spirit of melody found me,
  And taught me in visions and dreams."

"For the sound of a chorus of voices
  Came gathering up from below,
And I heard how all Nature rejoices,
  And moves with a musical flow.
O strange! we are lost in delusion,
  Our ways and our doings are wrong,
We are drowning in wilful confusion
  The notes of that wonderful song."

To appreciate Maxwell's relation to theories of electrical action, it is desirable to take a retrospect of the views that have been held regarding its nature. Three periods in the history of these views may readily be distinguished. The first was introduced by Dr. Gilbert in 1600, and it lasted for about 225 years. The little that was known previous to Gilbert constitutes only the preface or introduction to the history proper. Nearly three-fourths of this period was utterly barren and unfruitful. It knew nothing better than unctuous effluvia and electric atmospheres. In the latter half of the period the Newtonian philosophy had become the orthodox doctrine. The great success attending the mathematical investigations, founded upon the law of inverse squares, naturally carried with it the acceptance of the underlying hypothesis of "action at a distance." There were not lacking, indeed, men of deeper philosophic insight who denied this doctrine, which they looked upon as entirely unphilosophical and which must utterly bar the way to any inquiry into the process by which the law is executed. Action at a distance by attraction or repulsion, varying inversely as the square of that distance, means an ultimate fact not admitting of further analysis.

The second period was one of contention. It began not with the important discovery of current electricity, nor of the electro-magnet, but with the philosophical methods and concepts of Faraday. The physical postulates of the mathematical school were entirely alien to the views which he adopted. "Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centers of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the Electric fluids."[6] Prior to Faraday the supporters of a medium to explain electric and magnetic action were always thrown out of court for lack of evidence; Faraday gave them a legal standing by furnishing the facts and evidence on which they could well afford to base their case.

The corpuscular theory of light, which had shown such remarkable vitality, was now in the last stages of a fatal disease, due to indigestion and lack of assimilation. Foucault finished it off in 1865 with his crucial experiment to decide upon the relative velocity of light in air and water. The undulatory theory was thus fully established, and the doctrine of radiant energy in general began to be clearly apprehended. The grand generalization of the conservation of energy was looming up all along the horizon of science, as the towers and spires of a great city appear to

4. Exp. Researches, 2,221.
5. Exp. Researches, 3,277.
6. Maxwell's Elec. and Mag., p. x.

rise out of the sea to a traveler approaching the land. Victory was ready to perch on the banners of an army contending for the ether doctrine—not a decimated army, but one constantly augmenting in numbers by deserters from the enemy. At this period, sixteen years ago, appeared the epoch-making book of Maxwell on Electricity and Magnetism. Its author professes only to translate Faraday's ideas into mathematical language; but he did vastly more than this. He demonstrated mathematically that the properties of the medium required to transmit electro-magnetic action are identical with those of the luminiferous ether. It would be unphilosophical, he remarks, to fill all space with a new medium whenever any new phenomenon is to be explained; and since two branches of science had independently suggested a medium requiring the same properties to account for the same phenomena in each, the evidence for the existence of a single medium for both kinds of physical phenomena was thereby greatly strengthened. The step from identity of the medium to identity of phenomena, that is, that light itself is an electro-magnetic phenomenon, though it may now seem to be a short one, must nevertheless, upon careful consideration, always be accepted as evidence of the greatest genius. To walk in Maxwell's footsteps now and take the very steps he took is one thing, and a comparatively easy one; but to make original explorations into unknown regions of nature, and to tread where no human being has ever before set foot is quite another thing. The electro-magnetic theory of light must be regarded as a great generalization, inferior only to that greatest one of all time—the conservation of energy.

The principal criteria upon which Maxwell relied for the confirmation of his theory may be briefly enumerated:—

1. An electro-magnetic wave or undulation is propagated through the ether with a velocity equal to the ratio of the electro-magnetic to the electrostatic unit of quantity. If light is an electro-magnetic phenomenon its velocity must also be equal to this same ratio. The very close approximation of the one to the other, as determined by a variety of methods, has been known for some time.

2. The specific inductive capacity, K, of any transparent dielectric should equal the square of its index of refraction. The discrepancies at this point are so great that all one can say in the most favorable case is that K is the most important term in the expression for the refractive index, while in other cases no confirmation whatever can be drawn from this class of evidence.

3. The magnetic and electric disturbances are both at right angles to the direction of propagation of the wave and at right angles to each other. The mathematical form of the disturbance agrees with that which constitutes light in being transverse to the direction of propagation. Further, the *electric* disturbance should be perpendicular to the plane of polarization of plane polarized light.

4. In non-conductors the disturbance should consist of electric displacements, but in conductors it should give rise both to electric displacements and electric currents by which the undulations are absorbed by the medium. Most transparent bodies, it is true, are good insulators, and all good conductors are opaque. The degree of opacity is, however, far from being proportional to the conductivity.

5. But perhaps the most important criterion of all is the one relating to the very existence itself of a medium. Such a test lies in the *time* element involved in transmission from point to point. Since energy is transmitted from a luminous body, as the source, to another body which may absorb it, then plainly if time is required for the transmission, the energy must reside in the medium by which the transmission is effected during the interval between the emission and the absorption. In the emission theory the light corpuscles are the receptacles of the energy and carry it with them in their flight. According to the undulatory theory the medium filling all space is the receptacle of the energy and passes it along from point to point by the action of contiguous parts.

Foucault's *experimentum crucis* proved the emission theory untenable. Roemer's observation of the retardation of the eclipses of Jupiter's satellites, when the earth is moving away from Jupiter, is, therefore, a confirmation of the undulatory theory of light and, in consequence, a demonstration of the existence of the luminiferous ether.

At this point the history of the nature of electrical action touches upon the third period.

The period upon which we have just entered may not inappropriately be called the period of confirmation. Nothing further appears to be necessary for the complete demonstration and establishment of the electro-magnetic theory of light. The noteworthy experiments of Professor Hertz, of Carlsruhe, are known to all. Rightly conceiving that the reality of electro-magnetic waves would be best established by the same experiments which would also establish the fundamental identity of such undulations with those of light, he had recourse to the principle of resonance or sympathetic vibrations for the detection of these long-period waves. By a device no less remarkable for its simplicity than its effectiveness he produced electrical oscillations of such rapidity that the waves in the surrounding region were short enough to be measured. This he accomplished by attaching to the secondary terminals of an induction coil two rectangular sheets of metal each supplied with a short, stout wire, ending in a small ball. The balls were brought near each other and the discharges of the coil took place between them. Under these conditions the discharge is oscillatory, and the period may be calculated by the formula of Sir Wm. Thomson, published in 1853.[7]

The receiving apparatus is also of the simplest design, consisting ordinarily of a circle of wire, interrupted at a point with an adjustable opening, and of such dimensions that the waves passing through the circle may set up electrical oscillations in it, synchronizing with those of the transmitting apparatus. The passage of sparks across the narrow opening of the circle indicates an electrical flow; and the necessity of adjusting the size of the circle in order to obtain this flow proves that the forces acting are periodic. The receiving apparatus must in fact be tuned so that the period of an electrical oscillation in it shall correspond with the external impulses absorbed. The intensity of the electric and magnetic disturbances is indicated by the relative length of sparks obtainable.

Equipped with this apparatus, which was installed in a large lecture hall, Hertz found not only that his tuned receiver responded to the impulses of the transmitter in the precise manner pointed out by theory, but that the sparks showed a series of maximum and minimum values recurring in periodic order as the receiver was carried further away from the source of the disturbances. The astounding fact was thus brought out that these electro-magnetic waves were reflected from the thick wall of the room, and that the combination of the direct and reflected systems produced stationary waves with loops and nodes that could be traced out by the responsive circle of wire. In this manner wave-lengths were measured down to 60 cms., and the *time element* was experimentally detected in the propagation of electrostatic and electro-dynamic induction. It was demonstrated that the disturbances producing the waves are at right angles to the direction of propagation, as Maxwell predicted, and as interference phenomena show them to be in light. Hertz has also found an electro-dynamic shadow cast by an iron post; he has verified the laws of reflection from plane and concave metallic reflectors, and has shown that electric waves suffer polarization and refraction in a manner exactly analogous to light. Professor Fitzgerald, of Dublin, has added another confirmation of Maxwell's doctrine, demonstrating that the *electric* disturbance is perpendicular to the plane of polarization as Maxwell's equations require. Finally, the velocity

7. Math. and Phys. Papers, vol. i., page 540.

of propagation of these electro-dynamic waves is found to be the same as the velocity of light. Thus not only have all of Maxwell's criteria except the second abundantly confirmed the judgment of the great physicist, but other proofs have been added. Electro-magnetic waves are therefore not merely like light, but they are light. Or perhaps, to speak more exactly, all radiant energy is transmitted as electro-magnetic waves in the luminiferous ether. Electricity has thus annexed the entire domain of light and radiant heat; and, as Professor Lodge says, "has become a truly imperial realm." The difference of wave-length in the three classes of phenomena is not a fundamental one. Increase the rate of the electrical oscillations a million fold in Hertz's experiments and the waves would not merely resemble light—they would be light. A wire through which such oscillations are surging back and forth would glow with light. Even the long heat waves would be absent, and only those producing the sensations of light and color would remain.

It will be observed that the oscillations of an electric discharge constitute the point of departure for the admirable researches of Hertz; and it is a matter in which we may modestly take a bit of national pride that the first case of electric oscillations was discovered by an American physicist. The oscillatory character of the Leyden jar discharge was demonstrated by Joseph Henry, in 1832, by means of the magnetic effects produced in small steel needles. It was not until 21 years later that Sir Wm. Thomson published the complete mathematical theory of such oscillations. They have since been observed directly by means of a rotating mirror. Dr. Oliver Lodge has lately shown that they rotate the plane of polarization of light in one direction and then in the other as they surge back and forth. He has also reduced the number of oscillations from several millions per second to a few hundred by increasing the capacity and the self-induction. The discharge then vibrates within the limits of audibility and produces a musical note.

The well-known experiment of Henry, in which he observed an induction current in a wire stretched parallel to and distant 30 feet from one which served to discharge a Leyden jar is now seen to have been a case of resonance; that is, the absorption of electric waves by a conductor, producing currents therein. And it is an evidence of the great genius of Henry, that he saw, somewhat dimly it may be, but still with a certain degree of rational apprehension, that the induction was transmitted across the intervening space with a velocity comparable only to that of light. He had perchance the divine touch of genius necessary for the great discovery of electro-magnetic waves coursing through the ether; but the way leading to this important physical fact had not then been sufficiently prepared and its discovery was impossible.

Waves similar to those from a Leyden jar discharge, but of longer period, are sent out from a wire conveying alternating currents. We must conceive of such a wire not simply as affected internally or even superficially by the electric energy surging through it, but as the source from which pulsate outward through the limitless ether, great waves of electro-magnetic disturbance. For 300 complete alternations per second, these waves are a million meters, or over 600 miles in length. They present a marked contrast with the waves corresponding to the D lines of the spectrum which are only about one five-millionth of a millimeter long.

These long waves from an alternating current represent energy. Through space it is conveyed with the velocity of light, and through other non-conductors or dielectrics with a smaller velocity, precisely as in the case of the radiant energy of light or heat. Henceforth the complete equation for the distribution of energy by means of alternating currents must include a term to express the radiation from the circuit. It may indeed be found that this term represents no inconsiderable part of the energy communicated to the wire in the case of very rapid alternations.

Thus we see that the ether plays a magnificent role in what may be called its dynamic relation to electric displacements. In its capacity as a reservoir of static or potential energy its agency has been better understood for a considerable period. When a continuous current begins to flow through a closed circuit a single wave travels out from the conductor; and during its progress, while the current is approaching its constant value, the enclosing ether is assuming its condition of static repose under stress. The whole ether, extending indefinitely outward from the conductor, is profoundly modified. We know how to map out the circular lines of force about it by means of iron filings; but the iron serves only to show what has already taken place in the ether before the filings are brought into the field. Every little iron particle becomes a magnet, with all the north-seeking poles stretching in one direction round the wire, and all the south-seeking poles in the other. What the mechanism of the stress, or the motion in the ether to produce these effects, may be we do not know; but we do know that these lines of force are all subject to a tension tending to shorten them, and that they are mutually repellant laterally. When a current is sent through a conductor the ether is expanded in concentric cylindrical layers about any straight portions of the circuit, and becomes the reservoir of potential energy. As soon as the current, which maintains this state of tension, ceases to flow, the stretched ether collapses upon the conductor, yielding up its energy in the form of self-induction. If a steady current is conceived as the setting up and breaking down of a static difference of potential energy at infinitesimal intervals of time, then the energy transmitted may depend upon a similar formation and decay of the static stress in the encompassing ether. The conductor is but the core of an electro-magnetic disturbance in the surrounding medium; and it may be that the enormous energy which a small copper wire can apparently convey is in reality transmitted by the invisible medium.

From this brief review of the theory of electric action it will be quite evident that henceforth the language applied to electrical phenomena must always include the luminiferous ether as a prominent term. The experiments of Hertz have made it impossible to explain electrical facts without taking this invisible medium into account. There is no such thing as electric or magnetic action at a distance. The ether is always an essential part of that complex system the interactions of which manifest themselves as electric or magnetic phenomena.

As the ear responds to the slow oscillations of an electric discharge through the intermediate agency of heat, so the eye of the mind responds to those more rapid oscillations, the existence of which has been demonstrated by experiment. No less clearly does the magnetic field appear as a system of lines of stress in the ambient ether. Definiteness has taken the place of the metaphysical speculations of earlier times. Complete ignorance has, at least, been superseded by half knowledge. We may not yet affirm with Edlund that the ether *is* electricity, but we are doubtless nearer a solution of this old problem than ever before.

"The discord is vanishing slowly,
  And melts in the dominant tone.
And they that have heard it can never
  Return to confusion again,
Their voices are music forever,
  And join in the mystical strain."

ARC LAMPS AND THEIR MECHANISM.[1]

BY PROFESSOR SILVANUS THOMPSON, D. Sc., M. I. E. E.

(Concluded from page 351.)

It would be impossible, in the scope of this paper, to dwell on the *hydrostatic feeds*, on the various modes of producing *vibrating feeds* and *hammering feeds*, which have been from time to time suggested. The notion of

1. Paper read before The Society of Arts, London, March 6, 1889.

having a *continuous* feed, the rate of which should be varied as required, is an enticing one, but it has never been made a practical success. Neither have the periodic methods of feeding, at which Mr. Brockie made so brave an attempt in 1881; the flavor of which indiscretion still clings about him in spite of the admirable lamps which he has produced in later years. Mr. Brockie's various forms of arc lamp would indeed well illustrate the whole range of the subject, and the same thing might be said about the numerous successive types of lamp produced by Mr. Crompton. Mr. Brockie has lately produced an excellent little projector lamp for use in the optical lantern, having the negative carbon pressed by spring against abutment screws of steel, whilst the upper carbon is fed forward by a nipping-lever controlled by a solenoid. *Abutment* lamps and *projector* lamps form separate classes by themselves, which cannot here be discussed.

Many of the points alluded to in the preceding descriptions are illustrated by the action of the De Puydt lamp, figure 23. This is a rack-train lamp which strikes its arc by lowering the lower carbon and raising the upper simultaneously, and feeds with a fly and detent controlled by a shunt-magnet. The main-circuit magnet, M, attracts obliquely its armature, rocking the train of wheels around the pivot of the first wheel. A lever, L, bent to an elbow which rests on the set screw, V, is also pivoted around the same arbor, and has a vertical arm which carries two attachments; a fork which engages on a pin on the train-frame, and a detent which arrests the fly. The other end of the lever, L, is held back by a spring, but can be attracted up by the shunt-magnet, S, when the detent is to be released in order to feed.

PRODUCT REGULATION.

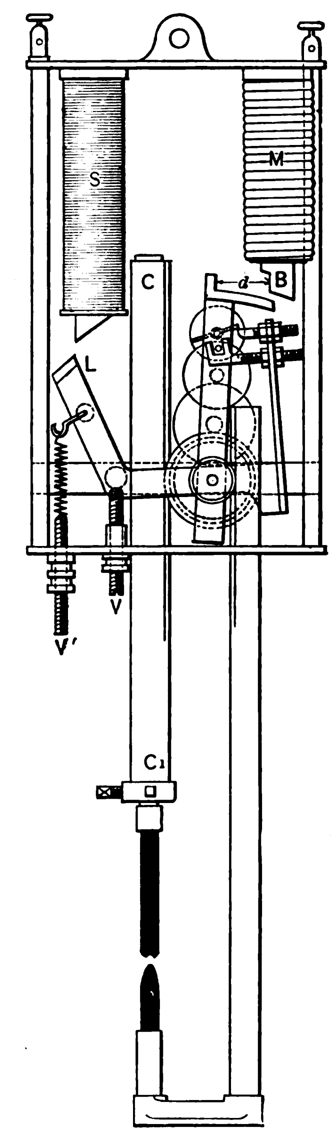
Before passing away from the feeding mechanisms, we may return to the question of revulsion in general, and in particular to the point that the function of the mechanism of the lamp is to maintain constant one of the two factors of the electric energy, the dynamo being responsible for the other. That part of the electric mechanism which controls the feed is responsible for the steady working of the lamp; and it is this which has to be sensitive to the fall of the current (in constant potential lamps), or to the rise of the potential (in constant current lamps). It is this which must control the feeding mechanism of the lamp. It may be remarked that the striking electro-magnet represents the muscle of the lamp, but the feeding electro-magnet represents the brains. Now, if the brains of the lamp have to think about, and control, one factor in the product, why can they be not made to think about and control the product itself? Such a lamp, in which the controlling part is neither an ampere-meter (main circuit) device, nor yet a volt-meter (shunt) device, but a watt-meter device, ought to make the lamp independent of any fluctuations in the supply. Product regulation is clearly in the abstract better than regulation either by the amperes alone or by the volts alone, or by the difference between them; and the mechanism is certainly such as can be constructed Such a lamp ought to run on any circuit. Let it be remembered that on a constant potential circuit a shunt-magnet can do no more than a spring might do. Neither can a main circuit magnet in a constant current circuit do more than a spring. A lamp in which both coils are properly combined, ought to be capable of working on either kind of circuit. Indeed, there are some existing lamps which will very nearly do so.

RELAY LAMPS.

It is evident that the brains of the lamp need not necessarily be placed inside the lamp itself; the device of using a sort of *relay*, outside the lamp, to watch the lamp and control its feed, is one that has been frequently suggested [Crompton, Abdank, Gerard, &c.]. There is one lamp [Jolin, 2,570[83]], in which a shunt relay, itself too weak to move the feed tilting-plate, does the work by opening and closing one of the circuits of a double, differentially wound, main circuit electro-magnet.

RETARDING MECHANISMS.

It would be very easy to write a whole chapter on fans, air dash-pots, glycerine dash-pots, and the innumerable devices which have been tried. Two are worthy of mention, namely, Hopkinson's device [153[81]] of altering the rate of feed by raising or lowering mercury in a vessel in which a fan is continuously rotating, and Brockie's suggestion of a liquid brake-wheel containing internal partitions, communicating by small apertures, so that a liquid could flow but slowly from one chamber to another.



DE PUYDT'S LAMP.

FIG 23.

REPLACEMENT MECHANISMS.

These may be classified as follows:—

(*a*) In rack-train lamps, a rachet wheel on first or second member of train.

(*b*) In clutch-lamps with loose clutches, none required.

(*c*) In forward feeding clutch-lamps, some device for loosening the clutch.

(*d*) In screw-feed lamps, some device for unclamping the screw gearing.

FOCUSING MECHANISMS.

The various ways of giving to the carbons the desired differential rates of approach are best classified by reference to figure 24, which gives four methods of pro-

ducing a motion of the carbons in the ratio of two to one, and four methods of "commercial focusing," in which the carbons are moved towards one another at equal rates.

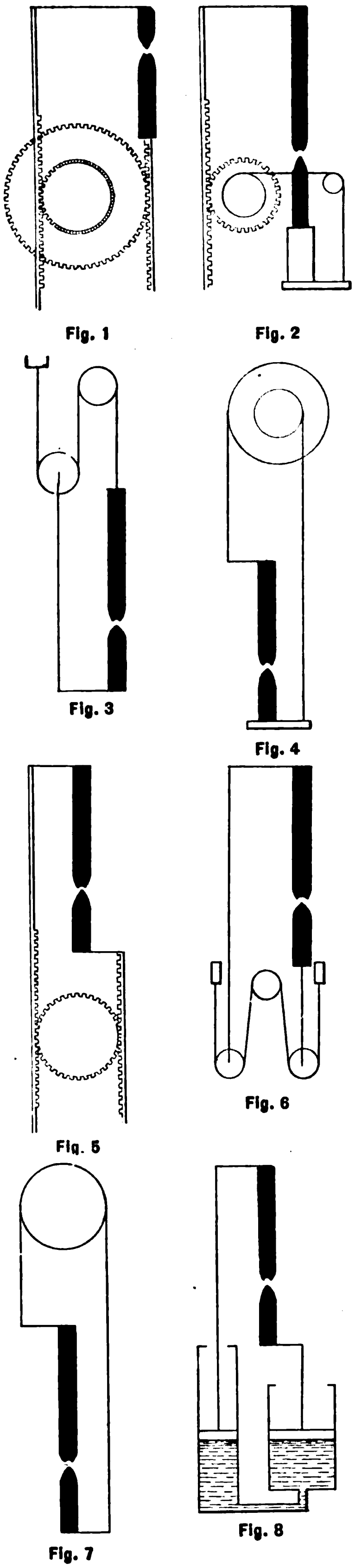


FIG. 24.—Modes of Focusing.

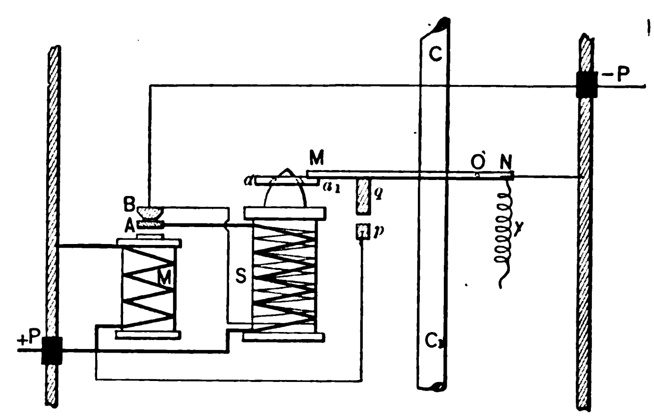
CHANGE-OVER MECHANISMS.

These may be classified into those which are purely mechanical [Brush, Thomson-Rice, Bürgin, Crompton-Crabb, &c.], and those which are electrical, the current being switched off from one pair of carbons, and switched on to another [Weston, 1,163[81]; Waterhouse, 5,185[81]; Trott and Fenton, 6,910[87]; Noble, 16,376[87]; &c.].

CUT-OUT MECHANISMS.

"Cut-out" mechanisms may also be purely mechanical; but they are more usually electrical, and, in modern forms, enable the lamp to "cut-in" again, on the re-establishment of its proper circuit. Cut-outs which enable a shunt-magnet to strike and feed the arc are described by Lever [8,443[84] and 11,501[84]], and are used in the Thomson-Rice lamp. The latest devices are those of Lauckert [5,707[87]], and Phillips and Harrison [7,235[87]]. In many lamps the cut-out circuit is merely a shunt electro-magnet stiffly set, which, on the failure of the lamp, receives the whole current, and pulls over a cut-out switch. Gerard [4,792[81]] describes several such devices, as well as a cut-out depending on expansion by heat. In the Pilsen lamp, figure 21, the cut-out is in an auxiliary main circuit. Cut-outs depending on the fusion of a wire or of a washer have been proposed by Lontin [2,094[77]], Basilevsky [5,026[84]], and McDill [1887].

The action of change-over and cut-out mechanisms is well illustrated by reference to the Thomson-Rice lamp, of which figure 25 illustrates the electrical mechanism, and figure 26 the mechanical mechanism of the lamp. The terminals are marked + P and — P. The carbon rods, C C and C_1 C_1, are held up by their respective clutches, which are identical with those of the Thomson-Houston lamp, figure 14, already described. The clutches, when the lamp is not at work, are themselves held up by the spiral springs, X X, which push down the levers, J and J_1, and push up

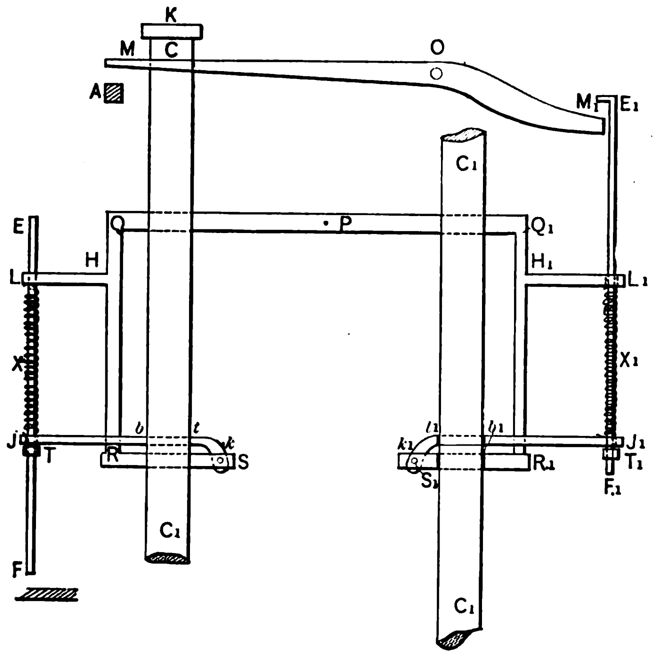


CIRCUITS OF THOMPSON-RICE LAMP.

FIG. 25.

the arms, H L and H_1 L_1, so gripping the rods. The principal electro-magnet, S, with its conical poles, has a pierced armature, *a a*, mounted on the end of a strong lever, M N, figure 25, which is pivoted at O, the short tail, O N, being pulled down by a powerful spring, X. This lever, thus held up above the poles of the electro-magnet, is connected to point P, figure 26, of the clutch-frame, and holds it up. The adjusting nuts of this frame are so set that when P descends the lower end, F, of the pin, E F, strikes on the base plate and opens the clutch for the left carbon-rod, so striking the arc of this pair of rods. When the pencils of this side are consumed, the rod, C C, has descended so far that its projecting head, K, strikes the long lever, M M, the other end of which raises the pin, E F, so bringing the other clutch into action. The electric arrangements, figure 25, are as follows:—The magnet, S, is wound with a few turns of thick wire, and with many turns of fine wire. The cut-out (or cut-in) magnet, M, is wound with coarse wire only. The upper carbon-rod is connected electrically to the frame of the lamp, whilst the lower carbon, insulated from the frame, is joined by a wire (not shown in the figure) to the negative pole. The current entering at + P passes first round the coarse wire on S, most of it going

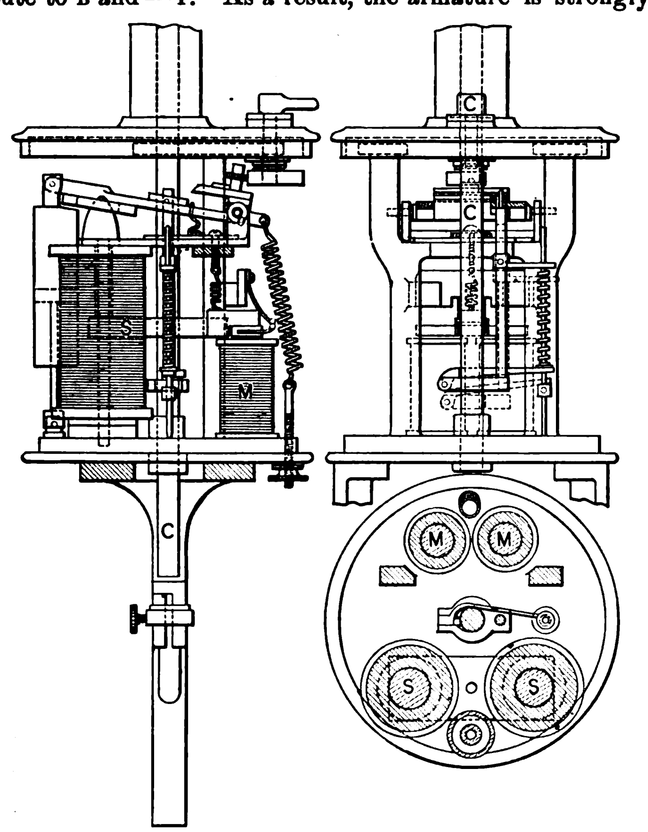
through A and B (which are in contact), and on to — P; but a little of it, after traversing the coarse wire coil, turns



MECHANISM OF THOMSON-RICE LAMP.

FIG. 26.

back along the fine wire coil and goes by this by-pass route to B and — P. As a result, the armature is strongly



GENERAL VIEW OF THOMSON-RICE LAMP.

FIG. 27.

M. The cut-out (or cut-in) electro-magnet which opens the contacts of the coarse-wire winding on the electro-magnet, S.

S. The principal electro-magnet, wound with fine and coarse wire. The armature of this electro-magnet is attached to a lever pivoted at O, and held at its other end by a strong spiral spring. This armature, in sinking, opens the clutch, and, in rising, closes it on the carbon-rod which it raises.

attracted, and the lever M N descends, causing the carbon rod to drop. This now opens another route for the current. Starting at + P, some of it will flow through M to the frame, thence through the upper and lower carbons and so to — P. This current will attract the armature A, and break the contact between A and B, breaking the coarse wire circuit through S, leaving the fine wire path still available. Consequently S loses most of its power, and the spring X pulls up the lever M N, so striking the arc. The shunt-circuit (fine wire) through S is still at work, and continues to operate the feeding, increasing as the resistance of the arc lengthens.

The present attempt to furnish a classification of the various mechanisms, electrical and mechanical, of the arc lamp, is probably extremely imperfect, but it may at least claim to supersede the old and ludicrous division of lamps into "monophotal" and "polyphotal." In conclusion, it may be pointed out that there exists a curious sort of family likeness between the several members of the three species of lamps most in use. The rack-train lamps, which may be considered as the prevailing continental type, are for the most part, in their design and construction, essentially clockmakers' lamps; they have a horological aspect. The clutch lamps so universal in America have a sort of sewing-machine look, the working parts being only finished where necessary for actual work, all else being left rough or merely painted over. The clutch-wheel lamps favored by British inventors have, in contrast to these, a look as though they had been designed and constructed by a trained engineer; they are essentially engineers' lamps.

APPENDIX.—SAMPLE OF FILLING UP OF SCHEDULE.

SCHEDULE OF ARC LAMP MECHANISM.

NAME OF LAMP.—Thomson-Houston. Single arc.

NATURE OF SUPPLY.—Constant current; *amperes* 9.8.

RESISTANCES.—*Main-circuit coil*, 0.09; *shunt*, 279; *cut-out* 0.85 *ohms.*

A	*Driving power*	Gravity on upper carbon-rod.
B	*Striking*	Main-circuit electro-magnet attracts lower end of see-saw, lifts clutch.
b	*ditto adjustment*	(1) Special resistance-coil shunting main-circuit coil. (2) Spring on tail of clutch.
C	*Feeding*	Shunt electro-magnet attracts upper end of see-saw, lowering clutch.
c	*ditto adjustment*	Same as b.
D	*Moderating*	Air dash-pot on horizontal tail of see-saw.
E	*Replacement*	None required.
F	*Focusing*	None.
f	*ditto adjustment*	None.
G	*Change-over*	None.
H	*Cut-out*	Insulated contact on lower end of see-saw, pulled over by shunt-coil, and puts cut-out resistance as shunt from + to — terminal.

DISCUSSION.

Mr. P. Sellon said it must have been a pleasure to all to listen to Professor Thompson's wonderfully clear and lucid paper; and the question he had brought forward was particularly interesting just at this epoch of electric lighting. Arc lamps were very prominent in electric lighting some eight or ten years ago, but since then there had been a general lethargy both on the part of electrical engineers and the public in regard to them, the develop-

ment of the incandescent lamp and the systems of distribution having almost monopolized attention. But just at this time, when electric lighting appeared about to have a chance at last, when they were really looking forward to a legitimate expansion in electric lighting from central stations, and might hope to see the streets of London and other large towns lighted in a way which would compare with towns in America and on the Continent, they were much indebted to Professor Thompson for again bringing forward this question of arc lighting. The question he had raised about the back electromotive force of the arc, or what was supposed to be back electromotive force, was a point well known to electrical engineers, and several theories had been advanced to explain the phenomenon; it would seem as if it was a number of thermo-electric couples between what the Professor told them was the point of volatilization necessary in an arc light, and the atmospheric temperature, so as to make up the 39 or 40 volts of the back pressure. With regard to the classification which Professor Thompson had given, he might perhaps be prejudiced in the matter, but he thought the distinction drawn between clockmakers' and sewing-machine makers' lamps, and engineers' lamps, was rather hard. He always classified lamps in his own mind as broadly divisible into two kinds—the arc lamp, which was non-retractile, and which was generally a lamp with electromotive force feed alone, the striking being done by an independent magnet or mechanism, the effect of which was that, as the release of the feeding mechanism required very little power, lamps of that order were exceedingly sensitive; and speaking broadly, they had far greater steadiness than in the other class, in which the electro-magnet had to do the double operation, not only the heavy work of striking the arc, but the light work of feeding the mechanism. Both these had their advantages. The latter were retractile; the other class were non-retractile, but, speaking generally, were more likely to give an absolutely unwavering light. The non-retractile might be called an egoistic lamp, and the other he considered as an enlightened altruistic lamp. The egoistic one, if put on a circuit with an altruistic one, would take great care to select for itself the amount of electromotive force required, and the more virtuous altruistic gentleman suffered in consequence. The effect had been that many altruistic lamps had got a bad name undeservedly, because the egoistic lamp would either burn exceedingly well or not at all, and unless the electromotive force furnished by the dynamo was sufficient for all the lamps on the circuit, they would go out entirely; but the altruistic ones would adapt themselves to varying conditions, and burn, though not so well, with an insufficient current; and as the tendency of human nature was to take as little trouble as would produce a passable result, want of attention had often given the latter a bad name. It was a case of external neglect rather than one proper to the lamp itself. Professor Thompson's course of reasoning seemed to have led him to a watt-regulated lamp as the beau ideal of what an arc lamp should be; and no doubt that was perfectly true, following that line of reasoning; but surely it should be remembered that arc lamps invariably ran either with a constant electromotive force or with constant current, and if you are dealing with either one set of conditions or the other, what function did the watt regulator fulfill? An arc lamp, in order to burn reasonably well, must have somewhere between 45 and 50 volts at the terminals, and it was no satisfaction to that lamp, if the electromotive force fell to, say, 40 volts, to know that it would raise the current up so as to bring the product of the electromotive force by the current to a given number of watts. Those who called themselves practical men had a tendency to think lightly of the work of professors, and to suggest that they merely served up a *réchauffé* of past history, and that it was the practical man who made all the advances. He did not hold that view himself, and it was quite impossible to justify it on listening to any of Professor Thompson's papers. He never listened to him on any subject without being struck by the way in which he not only carried his hearers' minds through a concise train of reasoning as to the past history of the subject, but also made practical suggestions, and gave narrowly defined lines upon which a genuine advance could take place in the future.

Mr. Rogers also thought Professor Thompson had been a little hard on some of the clutch-lamp makers: though it was some comfort to hear that if the lamps were rough, they were effective. All who had to do with the placing of lamps of that rough and ready class, knew that there were certain conditions which Professor Thompson had explained, which did not appear at first sight, which had to be attended to. However well you might make your moving part, after a time either the rod was abraded, or dirt got in and impaired the steadiness of working. He had experimented with some 20 or 30 different forms of clutch, and always found that was the main difficulty to get over. The motor-driven lamp referred to last he had been much struck with, but should like to ask one question about it. He believed some eight or nine lamps of the motor type had been made, but after some time there was a defect, which he thought he had noticed in that one; although it was exceedingly steady. After a time the lamps got warm, and then there was a tendency to retardation in the motor. In watching the lamp, he thought the later feeds—and there seemed about a couple of dozen feeds in all—were a little retarded, the arc became a little longer before it began to feed, but he did not know whether it was due to the cause he had suggested. One such lamp was in the Crystal Palace exhibition, and he rather fancied it had the same defect; but this was certainly the most perfect thing in the shape of feed he had yet seen.

Mr. R. J. Williams said he was not connected with any company, but he had had a little experience in putting up lamps, and he must say that he had found what were termed the rough and ready lamps the best in some cases, simply because you were obliged, in foreign countries, or in exhibitions, or in cases of emergency, to employ the workmen you could get on the spot, who were not always very skilled, and were often working under conditions in which dust and dirt were unavoidable; and in such cases the sewing-machine type (American) of lamp did its duty quite as well as any other, and, he thought, rather better, though he would not state that positively. He had chosen the Brush type of lamp, or one similar to that, for the lighting of the Kremlin at the time of the coronation of the Czar. He used them with rough Russians in the coldest of climates, and again in the hottest of summer weather, and, under both conditions, they did their makers credit.

Mr. Mordey thought the great difficulty with lamp manufacturers had been that they wanted to make one lamp which would do for every purpose. Many of these lamps would not answer, except, perhaps, under one set of conditions; but a lamp ought to be able to burn in series, parallel multiple series, constant current, constant electromotive force, and with an alternating current or continuous one, and manufacturers wanted to make one lamp which would do all these things. It would facilitate their work very greatly if they could turn out an article which would only want modifying in detail to effect all these objects. That was the reason why, though he had been connected with electric lighting a great deal, he had never tried to invent a lamp, and he was probably the only man in the room who had not. But in fact he was rather tired of it; he was connected with the Brush company, and as he found that under any passable conditions, given good carbons and fair treatment, the Brush lamp would burn at least as well, and taken all round, better than any other, he thought it as well to leave it severely alone.

Mr. Wyles said the Brush lamp burned very well at first, but then the rod got a little speckled; and he thought the fault lay in sending the current through the washer; and that if the connection were so arranged as not to have a moving contact, it would be better. The new form of Brush lamps was a great improvement on the old ones. With regard to the Brockie-Pell lamps, he found them work admirably; the electromotive force was practically constant, and he did not quite follow Mr. Sellon when he said they robbed the others if worked on the same circuit, assuming them to be working with the average electromotive force on the circuit. He should be glad if Professor Thompson would explain the connections of the Maquaire lamp. His experience was that the Crompton lamps required much more skilled workmen to attend to them, but they burned very well if properly attended to.

Professor Thompson, in reply, said he was not quite sure that he understood Mr. Sellon with regard to the egoistic and altruistic lamps, but he did not agree with what he took to be his meaning. He did not think you could divide lamps which had only one magnet from those which had both series and shunt magnets, and call them egoistic and altruistic. In the case of a constant potential, you did not require two magnets to get a retractile effect. For example, there was the Gülcher lamp, with a magnetic clutch, in which a single magnet fed and struck, and could move up or down, according to the requirements of the arc. It was retractile, and yet there was only one magnet. On the other hand, he could point to a lamp which had two magnets—a pot-magnet at the bottom to strike the arc, and another one at the top to regulate the feed with a shunt—which had nothing retractile about it, although there were two magnets. Why one should be called egoistic and the other altruistic he did not know. One would undoubtedly adopt itself to the conditions of the arc, and the other would not, but it was the altruistic one in this case which did not adapt itself to the surrounding conditions, and the egoistic one which did. He must beg pardon of Mr. Sellon and Mr. Rogers for having dared to compare the lamps of the companies they represented to the work of clockmakers or sewing-machine makers, but he would ask them whether the criticism was not in the main just; whether the class of lamp, as a whole, had not that characteristic about it. It was quite possible to have a sewing machine well made, and quite possible to have a clock which was a magnificent piece of engineering, not thrown together like the clocks which inundated the market from abroad. But he would remark, that not only was the voltaic arc itself discovered by an Englishman, Sir Humphrey Davy, but the first rack-train lamp was invented by Staite in 1847, and the first clutch by Slater and Watson in 1852; whilst, as for clutch-wheel lamps, we must claim them all. They were all equally English from this point of view; and it was perhaps rather characteristic of the people where they were used, than of the inventors, that

the Americans seemed to have adopted the clutch and the Continentals the rack and train. It was not for him either to condemn or to approve without reserve any one lamp, or to say which, of all he had mentioned, he gave the preference to. If any one wished to know which he considered the best, they would have to read very carefully between the lines of his paper; as a matter of fact, there was no best lamp, or, at any rate, he had not yet found it; but there were some which, take them for all in all, might be said to be as good as any other in the market, and there might be two or three for which that claim might fairly be made. Mr. Sellon objected to his notion that regulating by the product—by the watts instead of the volts or amperes—was possible, because arc lamps were habitually worked with constant potential or constant current. He quite agreed that theoretically you got over the variation in the quantity of energy supplied by having a mechanism which provided for the regulation of the one factor; but there were certain lamps which did not depend either on the current or on the potential, but on the difference between the two; the lamps being differentially wound. In fact, the differential winding, to keep the difference between the two quantities, instead of the product, constant, was one of the things which had been looked upon in the past as an important patent. Did not Mr. Sellon's argument apply still more strongly to such a form of lamp? If one of two factors of the product was constant, you kept the difference between that and the other constant, you virtually kept the product constant: but if, with one of the two supposed constant, you could not depend on the dynamo, then the difference between that and the other being kept constant would not regulate the light at all; the difference failed to have any meaning if you could not rely on one of the two things, between which the difference was to be taken, being constant. The attempt at product regulation was therefore essentially better than regulation by difference. With reference to the connections of Maquaire's screw lamp, it was difficult to explain them offhand, but he would endeavor to give some of the method. The large magnets must be taken as being wound in the main circuit with thick wire, but when you had got half-way through the winding, there was a branch taken off, which went to one of the brushes of the armature. This had a comparatively fine wire coil, and was virtually a volt-meter. This was, therefore, necessarily, a product-regulating lamp; because, if the armature were a volt-meter, the field magnets were in the main circuit, and were a sort of ampere-meter, the force which pulled the thing round would be proportional to the product of the two. But this was not a watt-meter in the proper sense of the word, because the armature was not taken as a shunt to the whole arc; it was only taken as a shunt to half of the coils of the field magnets. (Professor Thompson further explained the mechanism of the lamp by the aid of a diagram.) Mr. Rogers said he thought that he had watched the lamp feed about twenty times, but he thought he must have been mistaken, because the little armature did not remain constant more than 10 seconds together when the lamp was in operation, the regulating wheel was continually in motion, the one revolution of the wheel made an extremely small difference in the position of the carbons. (The lamp was again put in operation to illustrate this). He did not think the heating of the motor, as suggested, would seriously affect its performance, and he did not see why it should affect this mechanism any more than the operation of a clutch. He thoroughly believed in a rough and ready lamp for rough and ready work; but rough and ready work, such as was admissible in illuminating the Kremlin or lighting a "city" in the backwoods of America, was not the kind of work which would be sufficient when a contract for lighting the City of London had to be fulfilled.

SPRAGUE SYSTEM FOR ELECTRIC RAILWAYS.

THE advance of electricity as applied to the propulsion of street cars has indeed been remarkable. About two years ago there were a few experimental electrical roads in operation, but street railway men, as a rule, especially those connected with large corporations, did not seriously contemplate the substitution of electricity for horses, or mules, or the cable, as a means of propulsion. About this time, however, a syndicate of capitalists secured the franchise for an electric street railroad in the City of Richmond, Va. The grades on the road were such that the use of horses as a motive power was impracticable. It was at first determined to put in a cable road; but as several of the electrical companies were at this time advertising their systems for propelling street cars by electricity, the question of using this new motive power was seriously considered, with the result that a contract for the electrical equipment of 12 miles of street and 40 cars was finally awarded to the Sprague Electric Railway and Motor Co. It was certainly a great undertaking for a company which at that time had not a single electric road in operation to undertake the equipment of a road the size of that at Richmond. But the Sprague company rightly assumed that if this road, presenting as it did, all the difficulties to be met and overcome in street railroad practice, could be equipped and successfully operated, then all questions as to the feasibility of this new application of electricity would be met and its adoption would become general throughout the country. The past two years have amply proved the correctness of this assumption.

In starting work on the Richmond road the Sprague company naturally had to follow ordinary street railroad practice as far as the road-bed, track and cars were concerned; but certain principles were determined upon in the electrical installation, which principles, embodying as they did then, and do now, the distinctive features of the Sprague system, may be briefly enumerated as follows:—

1st. It was determined to place the motors entirely beneath the car. This was an entirely new departure and

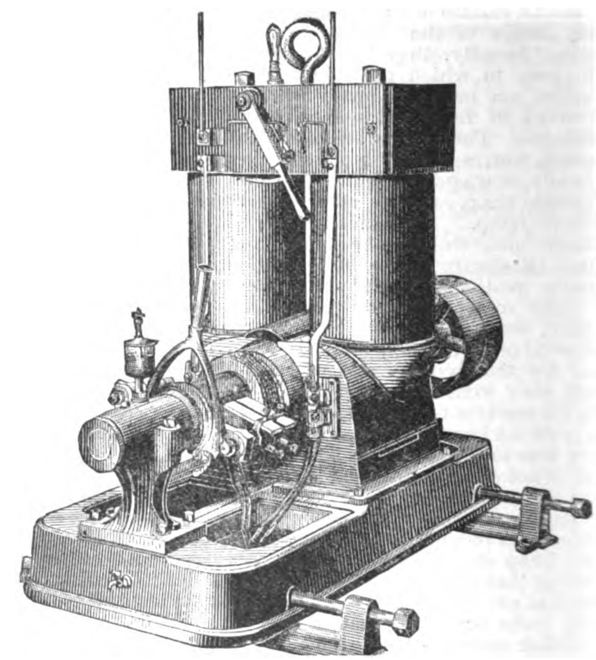


FIG. 1.—Sprague Electric Railway System. Compound Wound Dynamo.

evoked at that time the ridicule, not only of street railway men, but also of many electricians.

2d. In order that the whole weight of the car might be available for traction two motors were used, each driving, independently, one axle.

3d. The motors were centered on the axle; direct gearing was used throughout—there being no sprocket wheels and chains.

4th. In order to relieve the gearing, bearings and moving parts of the motor from the inevitable strains and jars to which they would be subjected in their novel position, the ends of the motors furthest from the axles were sustained in position by a yielding support.

5th. It was determined to control both motors from a single switch placed on either end of the car; the necessary variations in the speed of the motors to be obtained by varying the resistance of the field winding of the motors traversed by the current; thus using no external resistance whatever.

6th. It was determined to carry the supply current on a main conductor strung on poles at the side of the street and feeding at proper intervals into a smaller working conductor, placed over the centre of each track, against which the contact wheel should press. Owing to the great length of the line, four main feeders were run

from the power station and tapped into the main current wire at four several points, to maintain the electrical pressure substantially constant. The return circuit was established through the rails and ground, the rails being connected together electrically by means of copper bands and reinforced by earth plates sunk into the ground at intervals along the line.

7th and last, it was decided to use an under-running contact wheel, supported on a suitable movable arm from the top of the car.

These principles were faithfully embodied in the Richmond road, and they are to-day the principles upon which all electric railways of any magnitude, using the overhead construction, are successfully operated. They are claimed to have been determined upon and enunciated by Mr. Sprague before one of them had been tested in practice and before the Sprague company had a single road in operation. The fact that every successful electric road in operation in the country to-day embodies some or all of these principles is the best practical proof that they were as sound then as they are now.

The Richmond road served to illustrate the success of electric traction on a large scale and under typical conditions of difficulty. To-day, as a result of its success the records show that more than 100 electric roads are either in operation or building, comprising about 400 miles of track and nearly 1,000 cars. The Richmond road demonstrated clearly that electric motors could carry heavily loaded cars up grades as high as 10 and 12 feet in a 100, at a speed of five or six miles an hour; that cars could be forced over tracks covered with mud and ice in winter; that they could be run at a speed of 15 to 20 miles an hour on the level; that motors could be put under the cars within three or four inches of the ground and run in that position 18 or 20 hours a day, day after day, exposed to the influences of the weather and to the dust, dirt and mud of the streets; and last, but not least, that cars could be operated by electricity at a cost very materially less than that of horse or cable traction. These were the very facts which street railway men questioned, and they were facts that could only be successfully proved by actual demonstration on a sufficiently large scale. The deduction to be made from these facts is plain and simple, namely: that the electric motor will rapidly replace all other forms of motive power on street railway work.

The overhead system will undoubtedly be retained in smaller cities and towns and in the country, connecting towns, while the storage battery, which is rapidly assuming a practical and successful form for street railway work may be utilized in large cities where the overhead rights cannot be obtained, and where the grades do not exceed five or six feet in 100.

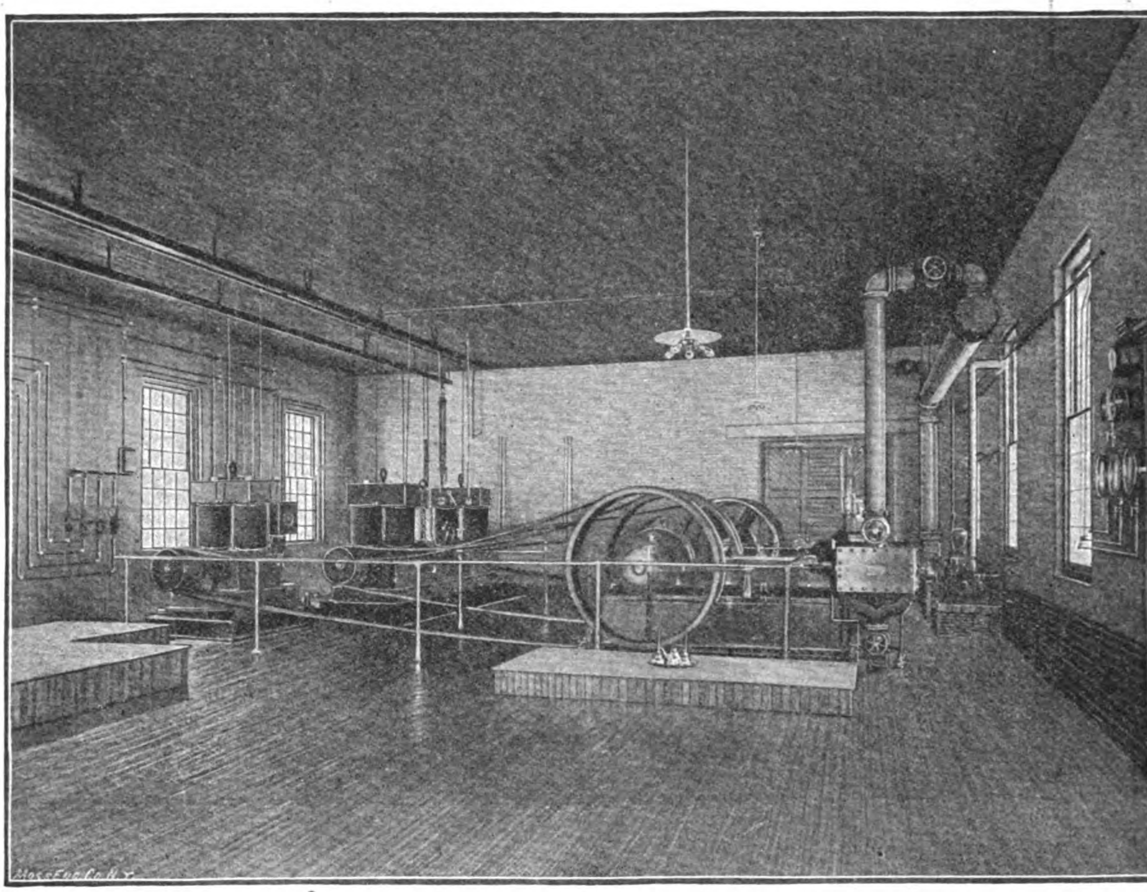


FIG. 2.—Sprague Electric Railway System. Power Station, Scranton, Pa.

POWER STATION.

In describing the Sprague system one naturally starts at the power station where all the experience and best practice of large lighting stations are taken advantage of to produce the most economical results. In some places a water power can be taken advantage of to drive water wheels belted to the dynamos; but in the large majority of cases the steam engine must be resorted to as the prime mover. In the economy of a plant much depends upon the style of boilers, furnaces and engines used, and the Sprague company has given great attention to these details. In estimating on the power required at the engines, about 10 h. p. per car is usually allowed which gives an ample reserve capacity. Thus, in Richmond, where the grades are very heavy, the average electrical horse-power per car at the station varies from 4 to 6; in Scranton, where the grades are equally heavy, about 5; in Cleveland, where the road is level, but where tow cars are run and very heavy loads carried, $4\frac{1}{2}$; in Lafayette, Ind., where the duty is

comparatively light, from 2 to 3. Owing to the variation in the load on the dynamos the Sprague company now use compound wound machines (dynamo, figure 2) entirely. Much attention is given to the regulation of the engine speed in order to maintain a constant electrical pressure at the station. The proper and uniform operation of the cars depends largely upon this important feature.

Figure 2 shows the interior of the Sprague station at Scranton, Pa., from which it will be seen that great care is given to all those minor electrical details and fittings which go to make up the finished central station of to-day, whether used for light or power purposes. All wires leading into the power station are protected by lightning arresters; and in addition choking coils are placed in circuit with all the feeders, their object being to deflect a discharge of lightning from a path to ground through the dynamos and force it to go through the lightning arrester and thence direct to the ground.

ductivity is used. This enables the wire to be put up very taut, and at the same time leaves an ample factor of safety to withstand any unusual strain or weight that may be put upon it. In order that one section of the line may, if necessary, be cut out of circuit, as, for example, in case of a fire or accident on any portion of the line, sectional cut-out boxes are placed at intervals along the lines on the poles. On long lines where two or more main feeders are used the cut-out boxes are placed in the main current wire; one main feeder supplying each section of the line with current, and the trolley wire being divided in sections by insulating breakers. If now an accident happens on any section of the line, a short circuit for example, the safety fuses in the nearest cut-out boxes are blown and this section of the line is cut out, all the rest of the road remaining intact. On short roads, where there is only one main feeder, the cut-out boxes are put into the auxiliary feeders, which connect the main conductor with the working con-

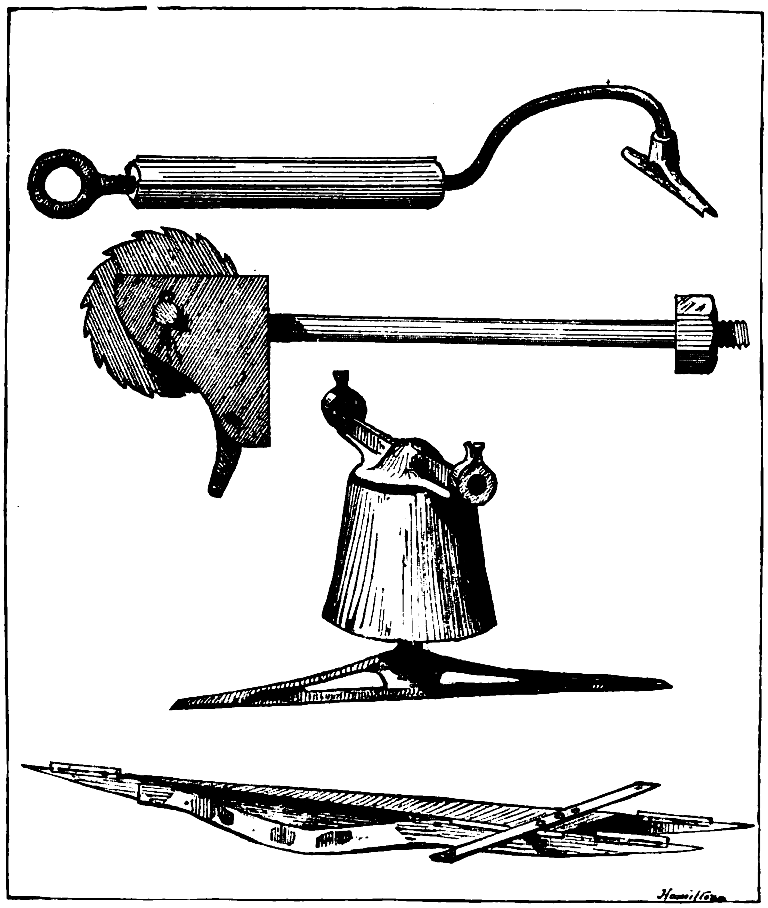


FIG. 3.—Sprague Electric Railway System. Trolley Wire Insulator; Pull-off Bracket for Curves; Pole Ratchet; Overhead Switch.

OVERHEAD CONSTRUCTION.

The distinctive characteristics aimed at in the Sprague overhead construction are efficiency, safety, lightness and neatness. Owing to the system of main feeders and main and working conductors, already mentioned, the electrical pressure can be maintained nearly constant on a line operating any number of cars, and up to a distance of about six miles from the station. The loss on the line varies from 5 to 10 per cent. In places where it is not desirable to carry the main current wire and main feeders on the side of the street overhead they can be readily buried in the ground, in suitable subways, leaving only one small wire over the centre of each track—that wire being ¼ inch in diameter.

In order that this working conductor may possess the necessary strength with its small dimensions, a silicon bronze wire of very high tensile strength and high con-

ductor or trolley wire.

Should a road increase the number of cars at any time in operation none of the line work is disturbed. It is necessary simply to put an additional main conductor on the side of the street, the size of the trolley wire remaining as before. This is an advantage where railroads equip portions of their roads with a view of increasing the equipment later. The use of a small wire over the centre of the street reduces strain on the supporting structure and permits the use of fewer poles, facilitating convenience in repairs. Where all the copper is put into the working conductor over the centre of the track a break at any one place in this wire stops all the cars beyond the break, and may necessitate the shutting down of the power station. In addition, if the number of cars on the road be increased beyond the original calculation this wire must be taken down and a larger one put in its place. With a line subdivided into sections, which can be made independent of

each other at will, only one section of the line can be disabled at one time and the liability of loss of traffic due to accidents or the shutting down of the road is reduced to a minimum. Many of the detail parts of the overhead system have been the subject of careful study and thought.

The line insulators which support the working conductor or trolley wire; the pull-off brackets, which support the trolley wire around a curve; the pole ratchets, for taking up the slack in the span wires; the overhead switches, for directing the contact wheel on to the proper wire, where two or more wires cross or diverge; the insulating breakers in the working conductor; the line cut-out boxes—all these details of construction have been carefully worked out and a long series of tests made to determine the most practicable and efficient designs and construction.

There is much opportunity for the display of taste and even beauty in an overhead line. Figure 4 shows the Sprague road in Atlantic City with a single line of iron poles between the tracks; the trolley wire being supported at the end of the cross-arms, held in position by ornamental brackets. Figure 5 shows the single pole line construction at Brockton, Mass., with side brackets on the poles; this construction is generally adopted on a single track road, where the track is on one side of a wide street. The double pole span wire construction is used where the track is in the centre of the street or where there are two tracks of a double track road so close together as to prohibit the use of a single line of poles between them.

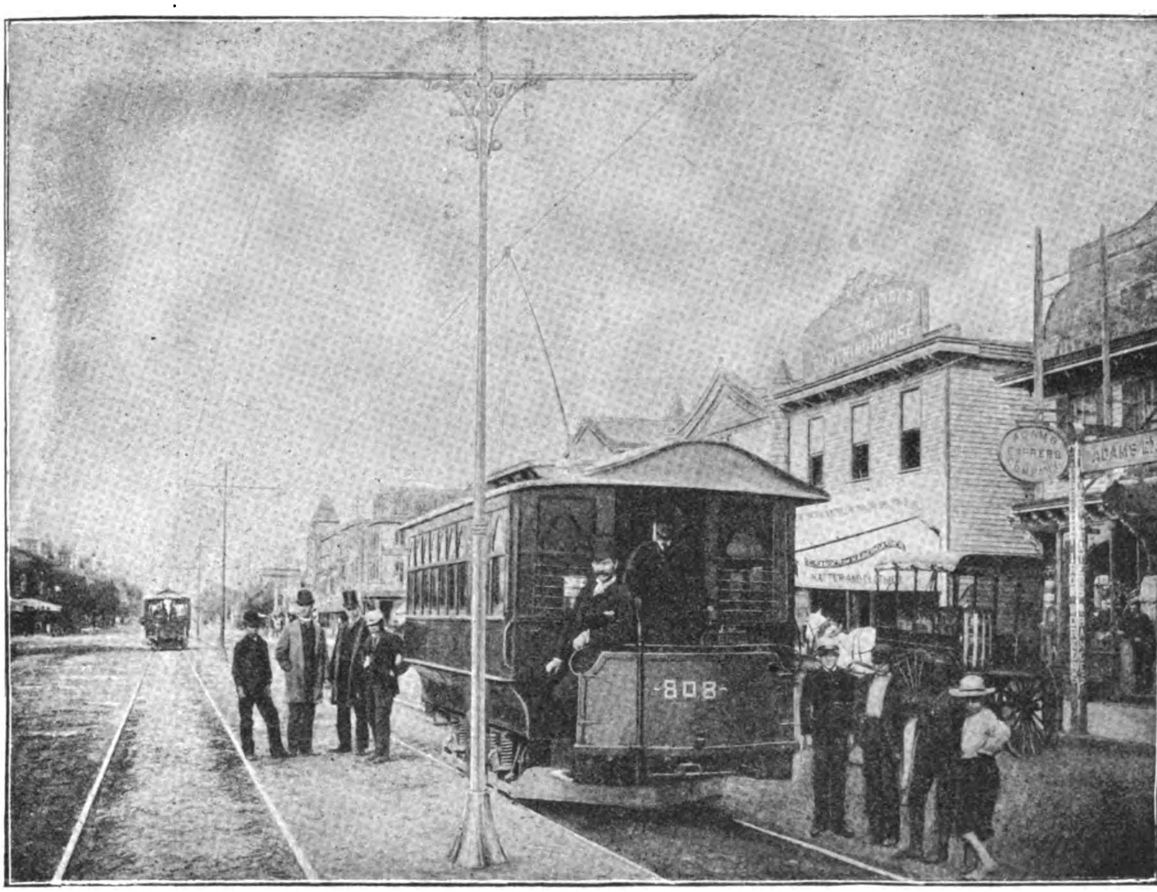


FIG. 4.—Sprague Electric Railway System. Single Iron Pole Line, Atlantic City, N. J.

CAR EQUIPMENT.

It is on this branch of the equipment that the Sprague company have spent the most time and study and where the improvements have been most marked. After a year's experience with the first motors used, the new Sprague motor, shown in figure 6, was designed, in which the fruits of experience with the earlier motors were embodied. The new motor, in its electrical and mechanical details of construction and in its efficiency has proved a distinct advance over its predecessors. Some of its essential features may be briefly enumerated as follows:—

All similar parts on similar machines are interchangeable.

All bearings of the armature and intermediate shaft are removable from the outside and interchangeable; the armature bearings are self-centering. The armature can be removed by simply removing one of the side brackets which support it, without dismounting the machine. The intermediate shaft can be removed from either side of the machine without dismounting. The gears are all independently removable without dismounting. All keys are abolished and replaced by feathers, with locking rings and cotter pins. All bolts have locking washers on them. The field coils are independently removable and waterproof. There are three ratios of gearing used on the machine, so that the motor may be geared for high speed on a level road, or slower speeds on roads where heavy grades are encountered. The proportions and relations of the armature, field magnets and windings have been carefully adapted for the production of the highest output and efficiency with the least possible weight. The motor can be applied to an ordinary street car or to any of the special independent trucks recently devised by various car companies for use in connection with electric motors.

The method of mounting the motor on the car is peculiar to the Sprague system, and deserves special mention. One motor is detachably centred on each axle so as to allow a yielding motion about the axle in any direction. In order to remove all shocks and strains from moving parts, and in order, further, to give the motor a yielding movement so that it may adapt itself to any change of load or any change in position of the car body or the truck, the end of the motor further from the axle is suspended flexibly from a cross sill on the car body above, or supported flexibly from below on the cross frame of the truck.

The best method of support is from a cross frame, carried by an equalizing bar on the axle boxes of an independent truck; this method gives the greatest freedom in the movement of the motor and allows it to accommodate itself most readily to any and all changes in the position or motion of the car body or truck. In addition, the flexible suspension enables a single motor in Atlantic City to start two heavily loaded open cars out of the middle of a curve so easily and smoothly that the motion of starting is scarcely noticeable by passengers; and this with no undue strain brought on any of the moving parts.

The Sprague company claim broad control by patents of the general method of flexible suspension, the importance of which is very obvious. They also claim a broad patent controlling the use of the main and working conductor.

and bringing the car to a stand-still. On each car a cut-out switch is provided, so that by the turning of a crank either or both motors can be independently cut out of circuit. In addition, each car has a safety fuse and lightning arrester; and the cars are brilliantly lighted at night by incandescent lights.

The contact with the trolley wire is made by a small wheel running on the under-side of the wire and pressed against the wire by the mechanism of the support, the latter being carried on the car top. The trolley support is mounted over the centre of the car, the rod carrying the wheel having freedom of movement in any direction, controlled by suitable springs; these movements allow the contact wheel to cling to the wire, even although the latter may vary greatly in height or in its distance from the centre of the track. Thus, in Scranton, the contact wire passes under two railroad bridges with less than 12 inches clearance from the top of the car, the bridges being separated only 150 feet; while between the bridges the wire is raised to a height of 22 feet where it passes over a railroad crossing. The side movement of the rod enables the wheel to follow the wire even when the latter is three feet to one side of the centre of the track. When it is desired to run the car in the opposite direction, the wheel is simply released from the wire and then placed on it again with the rod trailing in the opposite direction. The contact wheel is so constructed that it is self-lubricating, and the wearing rim or surface, made of phospor-bronze, can

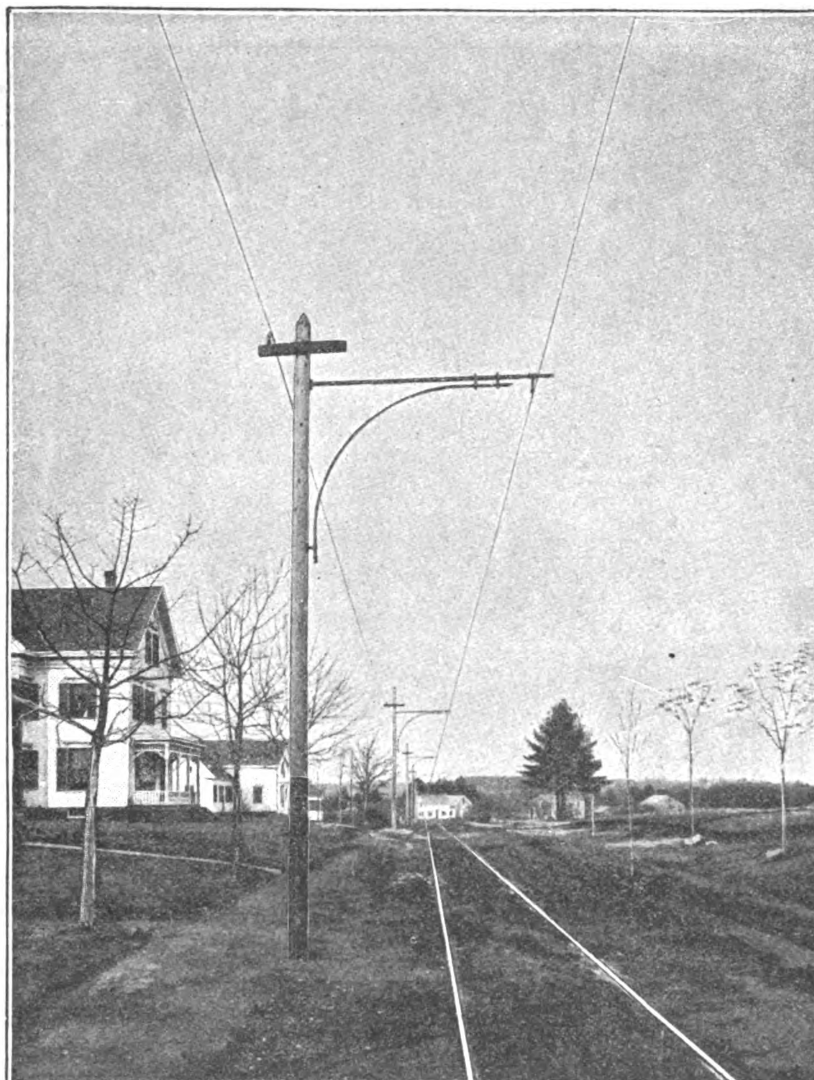


FIG. 5.—Sprague Electric Railway System. Bracket Trolley Wire Suspension, Brockton, Mass.

The motors are controlled on the car by a single movement switch on either platform; there being no external resistance between the motors and switch. By moving the switch handle one-half a revolution in either direction, the speed of the car can be controlled from the merest crawl up to a speed of 15 or 20 miles an hour. In order to show how quickly a car could be stopped, the controlling switch was suddenly reversed on a car in Cleveland with the car running 15 miles an hour, when the car was brought to a stand-still in a little more than its length. Thorough control of the motors becomes an important feature in crowded streets or where a car is running at a high speed. Two lives have been saved in Richmond by instantly reversing the motors

readily be removed when worn out and a new rim substituted in a few minutes.

The records of some of the Sprague roads show a remarkable duty for the cars; thus, in Scranton, with 17 cars equipped, every one of these cars has been in use daily, the grades on the road running from 6 to 10 per cent, and the loads carried being very heavy. The cars make from 70 to 80 miles per day, being an increase of 40 per cent. over the mileage previously made by horses. In Richmond, where the grades are heavier and the curves sharper than on any road in existence, and where both extend over long distances, 40 cars are in operation on busy days, this being the greatest number of cars ever operated on any electric road from a single station. In Atlantic City all the cars, 16 in number, are in continuous operation daily, and the loads carried are enormous; the cars make from 90 to 100 miles per day, and the 16 cars, with 9 tow cars, have carried in one day over 40,000 passengers. In Cleveland, where the motor cars also tow other cars, the mileage made is very high; thus, in May last, 17 cars made, in 487 car days, 45,640 miles, being an average of $93\frac{7}{10}$ miles per car per day. The maximum daily run was 193 miles, and one car, for nine days, made an average of 143 miles per day. These figures show the results which railway companies can obtain by the adoption of electricity.

In addition to increased car mileage, the cost of operation is also materially reduced. A year ago Mr. Sprague, in an article describing the Richmond road, gave some very elaborate figures on the cost of operation by electricity, including the cost of operating the power station, repairs, oilers, inspectors, etc. (see ELECTRICAL ENGINEER, August, 1888). At that time some of the figures were necessarily estimated, since no road had then been in operation a sufficient length of time to furnish reliable data; since then, however, data from several of the roads in operation have proved the accuracy of Mr. Sprague's estimate, and have shown, to the satisfaction of the Sprague company, that the cost of operation by electricity is from 4 to 5 cents per car mile, varying slightly with the cost of coal, the number of cars operated, the character of the road, etc., the average being about $4\frac{1}{2}$ cents per car mile.

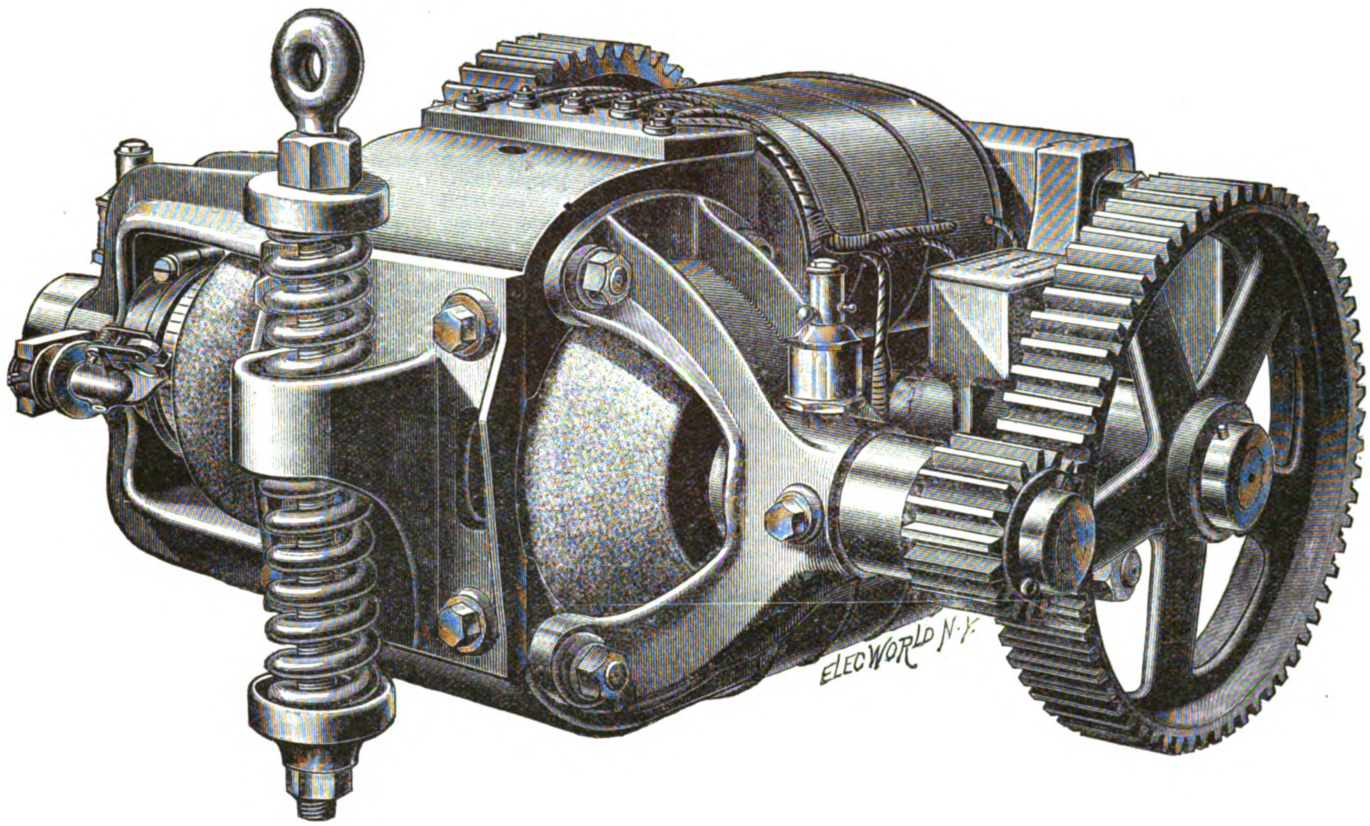


FIG. 6.—Sprague Electric Railway System. Car Motor.

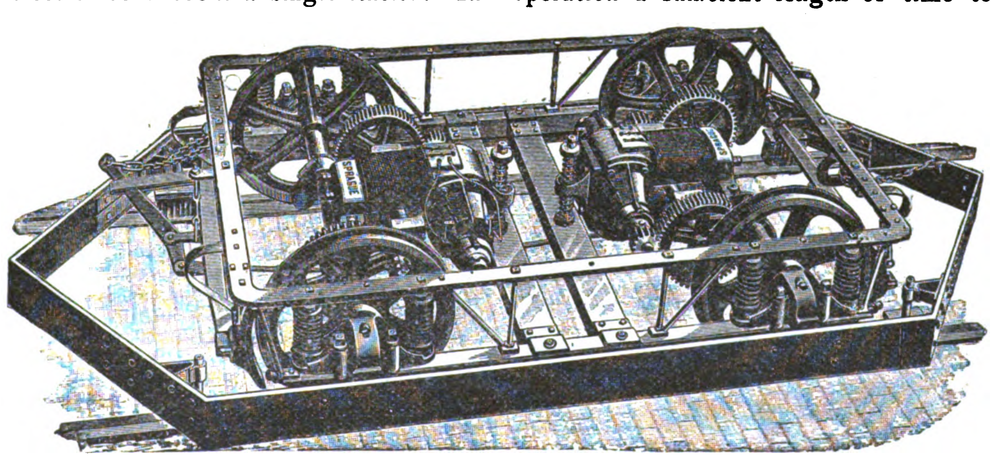


FIG. 7.—Sprague Electric Railway System. Car Truck with Motor.

This cost includes coal, oil, waste, depreciation and attendance at the power station, also water and taxes, oil, waste and brushes on the motors, repairs and depreciation; in fact, all operating expenses, including the depreciation on the line, excepting only the wages of motor men and conductors, and repairs on the road-bed. The corresponding cost of operation with horses may be taken to be from 7 to 10 cents per car mile, and with cables slightly less than those figures.

The adoption of electricity, then, on street railroads means to the railway companies increased car mileage and decreased operating expenses. To the public it means much faster, pleasanter and cleaner riding, with a corresponding increase in the distance which they can conveniently travel between their homes and their places of business.

Two years ago to-day the Sprague company had one little two car road, one mile long, in operation in St. Joseph, Mo.; to-day they report, either running or building, 60 roads, aggregating 200 miles of track and 400 cars; while the capacity of the Edison Machine Works, with its ample facilities for turning out electrical machinery of all kinds, is taxed to its utmost to keep pace with the demand for the new Sprague electric railway motors.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Appropriation made for Asphalt Paving.—Various Endorsements for Committeeman for World's Fair.—Removal of Wires on Lower Broadway.—Is the New Railroad Law Constitutional?—More Julien Cars on Fourth Avenue.—Proposed Reduction for Government Telegraph Messages.—No Report Yet in the Kemmler Case.—Mr. Thomas A. Edison Abroad.—The New Edison Station in Brooklyn.—Storage Battery Cars for the Jersey City Street Railroads.—Accident on the Electric Road at Newport.

THE board of estimate and apportionment, at their meeting of August 19th, decided to expend $200,000 for laying asphalt paving on the Boulevard from Fifty-ninth street north, on Lexington avenue from Forty-second street to Sixty-fifth streets, and on Broad street from Wall to Exchange place. The *Tribune* remarks, editorially, that a necessary preliminary to its [asphalt] general introduction, however, would be the construction of a sane system of subways enclosing all sewers, water and gas pipes, and wire conduits.

An effort is being made to complete the organization of a plan for holding a World's Fair in this city in 1892, and to this end the mayor has invited recommendations of a representative for each industry to serve on the general committee. The National Electric Light Association put forward Dr. Otto A. Moses; the American Institute of Electrical Engineers, Dr. F. B. Herzog; the Board of Electrical Control, Mr. Jacob Hess; and the New York Electric Club, Mr. Theodore N. Vail and Mr. H. C. Davis. It is to be hoped that an effort will be made to unite upon one man, and it is believed that one can be easily found who will be satisfactory to all alike.

The lower end of Broadway, from Park place to the Battery, will soon be entirely clear of poles and wires, their removal having begun on August 10th, and is being carried on during the early morning hours and Sundays.

There is some doubt as to the constitutionality of the recently passed railroad bill which permits surface railways to change their motive power to cable or electricity without the consent of a majority of abutting property owners. The new law vests this power in the state railroad commissioners.

President Bracken, of the Julien Electric Co., announces that additional cars will shortly be placed on the Fourth avenue line.

A series of communications have passed between the postmaster-general and Dr. Norvin Green, president of the Western Union Telegraph Co., with regard to the proposed government rate of one mill per word for official messages. The present rate is one cent per word, counting address and signature.

The Kemmler case is not yet decided. Hon. Bourke Cockran states that the minutes of the proceedings are in course of preparation, and the referee will then make his report.

Mr. Thomas A. Edison and wife are now in Paris, having sailed two weeks ago direct for Havre. It is said Mr. Edison intends to remain abroad two months.

The first of the Edison stations in Brooklyn is almost completed. It is located on Pearl street near Myrtle avenue. The building is three stories high, and designed much after the manner of the local stations in New York city. The contract for twelve 350 h. p. engines has been given the Ball Engine Co., of Erie, Pa.; and twenty-four 1500 h. p., 16 c. p. Edison dynamos will be placed in the second story. The mains will all be underground, and laid in iron tubes.

An electric motor car, with storage batteries, made one trip on the Broadway line in the early part of the month. It was said to be the system of the River and Rail Electric Co., but no definite information was obtainable.

Mr. W. D. Sargent, general manager New York and New Jersey Telephone Co., returned from Paris August 4th.

An effort is being made to introduce the storage battery system of electric traction on the street railways of Jersey City. An ordinance permitting the use of electric motors and storage batteries has been granted to the New Jersey and Bergen Point horse railroad.

There was plenty of excitement on board an electric car at Newport, August 18th. It seems that the driver allowed the car to run down the beach hill with the current shut off, the momentum of the car increasing to such an extent that one passenger became frightened and jumped off. When the driver heard of this he began to reverse his motor, this operation causing alarm to eight other passengers, who jumped out in a heap. Those who remained on the car were unhurt, the car stopping a few feet further on.

NEW YORK, August 24, 1889.

BOSTON.

Freaks of Lightning.—The Output of Telephones.—Advance in Telephone Stocks.—Fluctuation in Thomson-Houston Stock.—Electric Welding of Rails.—Street Railway Notes.

THERE have been some curious freaks of lightning in the recent storms hereabouts. Lightning struck a fence post near the Harrison square station, on the Old Colony railroad, and, going to within six or seven inches of the ground, it exploded with a loud noise, shattering the post to fragments. The telephone central station at Newtonville was visited by lightning, and of the 150 current protectors in the cable box 54 were burned out.

Lightning passed through the Jefferson physical laboratory of Harvard College. Striking the chimney it tore away the bricks and then passed down to the bottom. Fortunately no one was hurt, although many of the summer students were badly frightened.

An electric car, in Lynn, on the Highland circuit, was passing through Central square, when the lightning struck the overhead wire, running down under the car, burning off a wire and setting a part of the wood-work on fire. The passengers experienced only a slight shock.

An empty car on the Revere & Boston Electric Railroad was struck by lightning while standing still near Centennial avenue, the terminus of the road. Only the motor underneath the car was injured.

At Woburn, lightning entered the house of Dominick McDevitt, on Elijah street, wrecking some of the furniture and prostrating Mrs. McDevitt and her child. In North Woburn, the lightning played a curious freak. The tall chimney of a currying shop was left standing when the building was burned, and the lightning entered it at the northwest corner of the top, went down the flue for some distance, out on the south side, stripped off some of the outside bricks for a distance of about 25 feet, then re-entered the chimney and came out of the flue at the bottom, bringing along with it a lot of dust and dirt. The water pipes were burst in Wards 6 and 7, a large tree on Elm street was struck by the lightning, and the telephone and fire-alarm systems were made useless by the burning out of magnets.

The statement of the output of telephones by the American Bell company for the month ended July 20, is made public, and makes very poor comparison both with last year and the preceding months of this year. While there was a net increase to the credit of the previous six months of 250 instruments, this month's decrease of 743 instruments makes the result since the beginning of the fiscal year a decrease in the net output of 493 instruments. Every month since January until this month has shown a net increase. The average net output for the previous six months was 3,156, and this month is 1,424 below the average. With the exception of the month ended January 20, the gross output is smaller than any month this year. The comparative figures are as follows :—

July—	1889.	1888.	
Gross	4,122	4,485	Dec. 363
Returned	2,390	2,010	Inc. 380
Net	1,732	2,475	Dec. 473
Dec. 21 to July 20—			
Gross	34,338	34,046	Inc. 292
Expenses	13,671	12,886	Inc. 785
Net	20,667	21,160	Dec. 493

The talk of readjustment of the relations of the American Bell with its sub-companies (the North Western, South Western and City of Cleveland), whereby the arrangements between them will

be placed on a more substantial and permanent footing, has caused a buoyant feeling in telephone stocks—and Erie, which has been sole owner, but by the new arrangement is a joint owner with the American Bell company, in the above-named companies, advanced from $33 to nearly $39.

Thomson-Houston stock has been jumping about in the market during the month past. It comes from Lynn, that some of its friends sold out at 106 to 108, calculating to buy in a few points lower; that they bought the stock from 105 down to par and got all that they could carry, and then had to stop, and that when their support was withdrawn, the price broke par with a thud. So much for gossip. For fact there is the unmistakable fear of litigation, and the very natural disposition to realize profits as soon as the alarm sounds.

By the Thomson electric process of welding, the rails of street or steam railways may be welded together by electricity after being placed in position. It is proposed to have at every 300 feet a break, to allow for expansion and contraction. President Whitney is reported as saying that the application of this invention to the West End system will save the company an immense amount per annum. Any kind of rails can be thus welded, and on the West End lines power can be obtained from the wires now in use.

The Thomson-Houston company's engineers have already been over the West End Railway Co.'s entire line from Haymarket square to Franklin Park, via Sudbury and Tremont streets, Shawmut avenue, Dudley and Warren streets and Blue Hill avenue, and the points for the erection of poles for the overhead wires have been located. The track over this route is to be relaid, and the Johnston rail has been decided upon. It is probable that the electric line will be extended from Haymarket square to Charlestown and Somerville, and thus electric cars will run the entire distance from Somerville to Franklin Park. The work of equipping the line from Cambridge street through Charles to Park square is progressing, most of the poles being already up and the cross wires strung. When this is completed electric cars will run from Harvard square to Park square. After the Franklin Park line is equipped, it is thought the line from Park square to City Point will be attended to, and thus all the cars between Harvard square, Cambridge, and City Point, South Boston, will be run by electricity. It is impossible to say when all this will be accomplished.

On the 8th, the officers of the Salem Electric Light Co. celebrated the opening of their new building on Peabody street, the construction of which was necessitated by the increased demands on the company. The building is of brick, two stories in height, 115 feet by 66, with boiler-house 90 x 50 feet. The station and its contents represent an investment of $75,000. The company was formed in 1881, being the third electric lighting company in Massachusetts. More than 400 guests, including the mayor and leading business men, inspected the new building.

The Quincy & Boston Street Railway Co., in preparation for running the railroad by electricity, has been stringing its wires on poles through the square in Quincy. In many instances the company utilized the poles of the New England Telephone Co. for that purpose. Last night Superintendent Hanson of the telephone company cut the wires from a few of the poles running through the square. The matter is now to be investigated by the mayor.

An association of the dealers in gas and electric light fixtures and fittings has recently been formed in this city. The members say that "the introduction of electricity as an illuminator, the great detail and vigilance necessary to satisfy all classes of trade, has demonstrated the advisability of rules to govern all alike." To that end the following-named officers have been chosen:—William Hollings, of R. Hollings & Co., president; C. H. McKenney, of C. H. McKenney & Co., N. W. T. Knott, of N. W. Turner Co., William P. Shreve, of Shreve, Crump & Low Co., J. C. Hollings, of R. Hollings & Co., Warren Kinney, of Warren Kinney & Co., executive committee; E. S. Batchelder, of the Bradley & Hubbard Manufacturing Co., secretary and treasurer.

BOSTON, August 16, 1889.

CHICAGO.

Reception and Banquet of the Chicago Electric Club.—An Opinion of the New York Electrical Execution Law.—Professor Barrett on Underground Wires in Chicago.—Success of the Chicago Edison Co.—The Electric Motor Trade.—Long-Distance Telephone Lines.—Chicago Bestirring Itself to Secure the World's Fair of 1892.—Litigation on Steam Engine Patents.—A Decision for the Ball Co. of Erie.—Mr. T. P. Conant Leaves Chicago to Become General Superintendent of the United Edison Co. of New York.

THE social event of the season in electrical circles was the reception and banquet of the Chicago electric club attending the opening of its new rooms, August 1st. The dedicatory exercises were on an elaborate scale, and were thoroughly enjoyable. The rooms of the club were handsomely decorated and brilliantly illuminated. The three upper floors of Kinsley's, which are connected with the club rooms, were thrown open for the use of the club. Guests to the number of 200 were present. Mayor Cregier, city electrician Barrett, fire marshal Swenie, and many prominent electricians from other cities were present. Music was furnished by an excellent orchestra, a mandolin quartette, accompanied by guitar and harp, and a vocal quartette. Another attraction was a phonograph in the club parlors, which entertained the guests during the evening. After partaking of an elaborate banquet, the guests were called to order by president Barton. W. A. Kreidler, chairman of the committee which had charge of furnishing the new rooms, made his report, and in an appropriate address formally delivered the new quarters to the president. In replying president Barton reviewed the history of the organization, and in the course of his remarks said:—

"I desire to thank you for your attendance in behalf of the club, and trust that the impressions made will be lasting, and that you will attend every subsequent meeting during the winter. Few of us there are who have not passed through the experience of first going to housekeeping. We are going to convince the ladies to-night that we can give them some points on housekeeping. We have had a brief period in which to organize our kitchen and culinary department, but from the display in front of you, and what will follow, I think there is not a lady here who will not agree that we know how to cook, and that we know how to set a table. My admonition would be: 'ladies go home and do likewise,' were I not afraid that if you did the club would never see its members again. Let us congratulate ourselves to-night that our quarters are so pleasant, and thank the committee heartily for having succeeded in securing us everything which seems to be desirable for our comfort and convenience. The secretary has reminded you of the quarters you first occupied. I think we had better not ask you to make any comparisons, but congratulate yourselves that you have prospered in this world's goods, and are now reaping the reward of patience, industry and honest toil. You have moved into a mansion. The same enthusiasm displayed for the ensuing two years that has been displayed for the last twelve months will put you into a palace."

Mayor Cregier responded to the sentiment: "The City of Chicago." He complimented the organization on its success, the beautiful rooms it occupied, and its membership.

Mr. M. M. M. Slattery, of Fort Wayne, Ind., gave an interesting discourse on what electricity has done for the Nineteenth century.

Mr. A. K. Stiles spoke for the ladies; and city electrician Barrett closed the speech with a few appropriate remarks.

The guests repaired to the dancing hall, and the festivities were continued until a late hour.

An associate member of the National Electric Light Association, on his return to Chicago from the recent convention, was asked by a representative of the ELECTRICAL ENGINEER for his opinion as to the advisability of executing criminals by electricity. While he would not care to have his name published, he certainly cannot find fault if those who read his remarks make shrewd guesses as to his identity. "What do I think of electrical executions? My conviction that the New York law was highly insulting to the electrical fraternity has been strengthened greatly by hearing what others said on this subject. As far as I know this is the only instance in which a man deliberately endeavored to debase the science on which he depended for a livelihood. If I had my way, I'd sentence such a man to 100 years in the old quarters of the Chicago Electric Club. As people begin to know more about this matter, they appreciate the advisability of repealing the law. The decided action of the Electric Light Association in dealing with this question was one of the most creditable things done at the convention. The members can at least look back on the passage of that resolution, and their recommendation that the duty on copper be abolished, as the most significant and sensible acts of the convention."

"We have now 6,000 miles of electric wires underground in Chicago," said city electrician Barret, a few days ago. "We have demonstrated that the system which we employ is successful. There was a time, you know, when companies used inferior material, so as to cause the system to be considered a failure, but those days are over. They have found that the wires have left the air permanently. They exercise proper precaution, and consequently there is no trouble. Our 6,000 miles of underground circuits are carried in 170 miles of two and three inch pipe. The city has 53 miles of electric light wire buried. I know that the long-distance telephone company says it has more trouble with its three miles of underground wire than with the remainder of its circuits. Shall I tell you why? Up to the point where the wires enter the ground the construction work has been splendidly done. If their wires were on poles, and the work done no better, they would experience the same trouble. The telephone company is doing a great deal in the way of improving its plant. I hope to see such changes made in the next year that the local lines will be as well built as the long-distance circuits. When that is done, there will be some satisfaction in using a telephone instrument. My belief in undergrounding wires grows stronger as my experience is more extended."

The Chicago Edison company closes its first year in a creditable manner. To-day 21,000 lamps are connected with the central station, and power is furnished a large number of motors in the

business portion of the city. Among the latest additions to its electric light list are Hooley's Theatre, where 1,000 lights are operated, and Central Music Hall, where a similar installation is being introduced. Many isolated plants have been installed by this company during the year. The latest is that at the "Libby Prison War Museum," which will be opened September 1st. The installation consists of two Edison dynamos, a Sperry arc dynamo, and two Armington & Sims' engines. There will be 640 incandescent and 20 arc lamps used.

The electric motor trade is rapidly assuming immense proportions in this city. Over 150 machines are operated on regular power circuits, and many others receive current from isolated plants.

The Long-Distance Telephone Co. has completed its line to Milwaukee, and is now operating five circuits. Its service is excellent, and already substantial evidence of the appreciation of its patrons is shown.

The business men of Chicago are working with their accustomed determination to secure the World's Fair for this city. B. E. Sunny, C. H. Wilson, and E. M. Barton represent the electrical interests on the general committee appointed by Mayor Cregier. This committee is hard at work, and New Yorkers will be obliged to get up and dust if they hope to outdo their enterprising western rivals.

In the patent suit brought by A. L. Ide & Son against the Ball Engine Co., Judge Blodgett, in the United States Court in Chicago, has handed down a decision in favor of the defendant. The complaint alleged infringement of use of dash pot in the governor of a steam engine.

Mr. Enos M. Barton, president of the Western Electric Co., recently returned from Europe, after an absence of three months.

T. P. Conant, of the firm of Conant & Hood, which represented the Electrical Accumulator Co. in Chicago, has accepted the position of general superintendent of the United Edison Co. of New York. Mr. Conant was popular here, and had earned a reputation as a thoroughly competent electrical engineer.

CHICAGO, Aug. 21, 1889.

PITTSBURGH.

Street Railway Notes.—A Contest for a Bridge.—Growth of Electric Traction in Pittsburgh.—The Business of the Westinghouse Company; Success of their Meter.—Public Lighting in Allegheny City.—Arc Light Extension in Pittsburgh.

THE Pleasant Valley Street Car Co., of this city, has stolen a march on the Pittsburgh & Manchester Street Car Co., by gaining the control of the Ninth street bridge, one of the connecting links between Pittsburgh and Allegheny. A few explanatory facts are necessary to make this statement somewhat clear.

The above two companies own all the competing lines between Pittsburgh and Allegheny. For years they have fought tooth and nail to gain sole control of all the bridges over the Allegheny river, and until a few months ago it looked as if the Pittsburgh & Manchester Co. were going to down their opponents by obtaining the right of way over some bridges and getting control of the stock of others. But suddenly the Pleasant Valley commenced to make a boom. They increased their capital stock from $200,000 to $1,000,000, absorbed an independent line, and made a contract with the Sprague Electric Co. for their system of electric street cars. But they were not quite secure yet, because they had not a single bridge under their control. This however, they accomplished last Friday, by buying the Ninth street bridge for $200,000. As the structure is one of the oldest bridges in the city, and a wooden one, they intend to pull it down and replace it with one of the finest iron bridges in the country. It will be fitted up with street car lines, two tracks for wagons, and two walks for pedestrians. The construction will be commenced by the first of September, and the electric cars are to be running next spring.

The Birmingham street car line was purchased a few weeks ago by H. Sellers McKee, a Pittsburgh millionaire, for $1,000,000. That is one of the oldest street car lines in the country, and Mr. McKee has made arrangements to operate the road in the future with the Widener-Elkins cable system.

Inasmuch as the cars have to traverse the Smithfield street bridge, which leads over the Monongahela river, an addition will be built to the bridge, enabling the street car company to lay its cables across the bridge without interfering with the present structure.

The revolution in the street car traffic of this city, which was called attention to in this correspondence last month is still going on. The Second avenue street car line will shortly be fitted up with the Thomson-Houston system.

Another street car line is being built between Allegheny city and Millvale, a small suburb, and the Sprague electric motor will be used.

The Duquesne Electric Co., who are the owners of patents on an entirely new system of electric street car locomotion, have laid a temporary line along Carson street for the purpose of experimenting with their system.

Work at the Westinghouse Electric Co.'s factory is constantly increasing. Orders were issued in the machine shop yesterday, that the men will have to work overtime again. The establishment has not been closed for a single day during the entire summer season, an unprecedented fact in the electrical manufacturing business. The electrical meter, which was brought out by the Westinghouse company about five months ago, is meeting with great favor wherever it has been used, and its general adoption increases day by day. It is now being used on 200,000 lamps of the Westinghouse system.

The Allegheny city councils who have been discussing the advisability of electric lights in the streets for some months past, at last passed a resolution to the effect that bids be accepted from any electric light company, on the condition that the company build an electric plant in the city and furnish the light for a certain length of time. If at the end of that period the city is willing to buy the plant it may do so. The bids are to be opened the first week in September.

The Pittsburgh arc light plant has been extended from the city line on Penn avenue, as far as Edgewood, and there is now a continuous line of arc lights from the Point in this city to Edgewood, a distance of eight miles.

An electric light company has been organized in Sewickley, a fashionable suburb about 12 miles from this city, and the poles are already being erected for the arc lights. The Westinghouse system is used by the company.

PITTSBURGH, August 20, 1889.

PARIS.

The International Exhibition.

THE United States was invited by the Republic of France in February, 1888, to take part in an exposition of works of art and the products of manufactures and agriculture of all nations, to be held in Paris, commencing the 5th day of May and closing the 31st day of October, 1889. Congress by an act, accepted this invitation, which was approved by the President of the United States, May 10, of the same year. The act provided for the appointment of a commissioner-general to represent the United States in the exposition and to make all needful rules and regulations in respect to exhibits from America, and to control the expenditures incident to the proper installation of such displays. The president was also authorized to appoint nine scientific experts corresponding and specifically assigned to the nine groups into which the exposition was divided, as assistants to the commissioner-general. Two hundred and fifty thousand dollars was appropriated to defray the expenses for the proper installation of the exhibition, and for the salary of the representatives of the United States. The allowance to the commissioner-general for salary and personal expenses was $10,000, to the assistant commissioner-general $5,000, to the nine scientific experts each $1,500, the allowance for clerk hire was $15,000. The following gentlemen were appointed by the president:—Commissioner-General, Wm. B. Franklin, Hartford, Conn.; Assistant Commissioner-General, Somerville P. Tuck, New York city; scientific experts, Rush C. Hawkins, New York city; Arthur J. Stace, Notre Dame, Indiana; David Urquhart, Jr., Helena, Montana; William H. Chandler, Bethlehem, Penn.; Spencer B. Newbury, Ithaca, N. Y.; Charles B. Richards, New Haven, Conn.; A. Howard Clark, Boston, Mass.; Charles V. Riley, Washington, D. C.; David King, Newport, R. I. The other officials are, Chief Engineer, Wm. C. Gunnell; Secretary, A. Bailley-Blanchard; Assistant Engineer, B. Abdank-Abakanowicz; superintendents of divisions, fine arts, J. H. Thieriot, group i.; education, C. Wellman Parks, group ii.; industrial, W. L. Bailie, groups iii., iv., and v.; machinery, T. R. Pickering, group vi.; agriculture, F. J. Bickford, groups vii., viii. and ix.; electricity, Carl Hering; minerals, George F. Kunz. Among the jurors appointed by General Franklin to represent the U. S. on the international jury are, Mr. H. B. Plant, railroad appliances; electricity, electric railway appliances, Mr. Carl Hering and Mr. B. Abdank. The 1st of July a formal meeting of the international juries in the great hall of the Trocadero Palace was called M. Tirard, president of the council and chief director of the exhibition, presided. The work was then begun, and is being pushed forward so as to get a report as early as possible. The work is even more tedious and thankless than usual, and the fights for awards keener. One excellent feature of the organization is that the president and vice-president of each jury are of different nationalities. There are 85 separate juries, and the total number of members exclusive of the experts is 900. It has been decided to grant awards as follows:—(*a*) Grand prize; (*b*) gold medals, (*c*) silver medals, (*d*) bronze medals, (*e*) honorable mention. The awards will be given in September. To give a slight idea of the undertaking and the colossal collection of exhibits in the exhibition, it will be enough to mention that the general French catalogue consists of eight octavo volumes. This is exclusive of catalogues which foreign sections have issued in their own languages, and of other special issues. The general classification of the United States exhibits should properly come

in here, but as the enumeration of the articles exhibited which are placed under groups and classes would take up much space, one may merely say that the nine groups into which the exhibition is divided are also again subdivided into classes, there being 83 classes in all. For instance: in the sixth group—class 62—electricity is divided thus:—

Production of electricity: Static electricity, batteries and accessories, magneto-electrical and dynamo-electrical machines, accumulators. *Transmission of electricity:* Cables, wires and accessories, lightning rods. *Electrometry:* Apparatus for electrical measurements, registers of electricity. *Applications of electricity:* Telegraphy, signals, telephony, microphony, photophony, electric light, electric motors, electrical locomotion, conveyance and distribution of force, transformers. *Medical electricity:* electro-chemistry. Electro-magnets and magnets, compasses, electrical clockwork. Various kinds of apparatus.

It must be apparent that the more hours per day an exhibition can be kept open, especially in the evening-time, the more chances there are of attracting people to it and making it a financial success. The executive of the Paris Exhibition of 1867, demonstrated the futility of trying to attract visitors to the buildings at night when it was illuminated, if we may use the term, by gas and oil. Later, the managers of exhibitions did not court failure by renewing the experiment, and therefore international exhibitions up to the year 1881 were not kept open at night. In the meantime—between 1867 and 1881—the electric light had got out of its swaddling clothes and had approximated to a commercial industry. The electrical exhibition held at the Palais de l'Industrie in 1881, where incandescent lighting was shown on a large scale, proved the utility of the light. There were then no less than 1,383 arc lamps displayed, of 24 different kinds. The success of that exhibition determined the lighting committees of the London, Manchester and other exhibitions, to adopt the electric light, and we know with what success. So early as August 21, 1886, M. Berger, the director general, wrote to the president of the Chamber of Electrical Industries, asking his advice and assistance. Several French electric light associations expressed their desire to co-operate, and it was decided that the central gardens of the Champ de Mars and other spaces within the enclosure, the great nave of the machinery hall, the 98-foot gallery in the middle of the miscellaneous industries courts, and other parts should be lighted, making the total area of 3,706,000 square feet. The expense for lighting the space for 180 nights has been estimated at $600,000. The exhibition administration arranged with the electric lighting syndicate (a body formed with the view of making the lighting an international undertaking), to supply the light and pay all expenses connected therewith; the executive paying the syndicate one-half the entrance money received in the evening. Should, however, the profits exceed $100,000, the administration reserved the right to share equally any additional gain. The syndicate correctly estimated that 2,000,000 candles would suffice to light the spaces in the Champ de Mars, and they accordingly had placed there 1,150 arc lamps and Jablochkoff candles and 10,000 incandescent lamps. In the machinery hall are 86 arc lamps of 3,500 candles each. The side galleries are illuminated by 200 arc lamps of 1,000 candles each, and 730 incandescent lamps are placed around the stairways. The 98-foot gallery has 52 arc lamps of 1,000 candles each. With the illuminated fountains, lamps varying from 5,000 to 10,000 candles are employed. Under the fountain basin is a water tight chamber, in which arc lamps are placed. These lamps are provided with colored glass screens, and direct their rays up, through suitable plates of strong glass, fitted water tight in metal frames. The electric plant supplying all these lights is grouped together in six central stations. The Gramme station has an area of 640 square meters, and the plant comprises nine Davey-Paxman locomotive boilers, three Davey-Paxman compound engines, developing a total of 700 h. p., two 175-h. p. dynamos and three 100-h. p. compound wound dynamos, giving 110 volts at the terminals. The Edison station has an area of 400 square meters, and the plant comprises four 150-h. p. Belleville boilers, four 150-h. p. Weyher and Richemond engines, two 100-h. p. and six 50-h. p. Edison dynamos. The Jablochkoff station, belonging to the Sociètiè d'Eclairage Électrique, has an area of 400 square meters, and a total available power of 600 h. p. The plant comprises four Ferme and Derharbe boilers, four 150-h. p. Leconteux and Garnier engines and 19 dynamos, viz., eight Gramme alternators, 10 Reckniewski continuous current machines and one Ferranti alternator. The station belonging to the Sociètè pour la Transmission de la Force contains two 500-h. p. Corliss engines, fed by multitubular Roser boilers and four 200-h. p. Marcel-Deprez dynamos. The Ducommun station contains 15 dynamos, having a total output of 300 electrical horse-power supplied by Lagosse boilers and Ducommun engines. The station belonging to the Syndicate International has an area of 320 square meters, and the total available horse-power amounts to 400, the boilers and engines being of various types. The electric plant consists of two 100 h. p. Borssat dynamos, one 50-h. p. dynamo, and another of 30 h. p., together with a Parsons's turbo-electric generator. The total power available for electric lighting purposes amounts to more than 3,000 h. p. There are also available 10,000 kilogrammes of accumulators. On entering the grounds of the exposition at the principal entrance, of course the first object noticed and admired is the Eiffel Tower. One is reminded of the Tower of Babel when viewing this enormous structure. It is not necessary to go back to scripture history to prove that M. Eiffel has not a monopoly of the idea of constructing a 1,000-foot tower, for there was the project of Trevithick in England in 1831; for a monument to commemorate the passing of the Reform Bill. It was to be 1,000 feet high, 100 feet in diameter at the base, and 12 feet in diameter at the top, and was to have a capital supporting a colossal statue. And there was also the proposal from Messrs. Clark and Reeves, of New York. Their idea was to construct a tower 1,000 feet high and 150 in diameter at the base, for the Centennial Fair in Philadelphia in 1876. And again, eight years ago, M. Sebillot suggested that Paris should be electrically lighted by a 1,000-foot tower. The majority of persons who admire the colossal height of the tower, have little idea of the number and complexity of the auxiliary services which the great work involved. Among these auxiliaries that of the electric installation is certainly the most interesting, and in confiding it to MM. Sautter, Lemonnier and Co., responsibility was placed in good hands. It is divided into three distinct groups. 1. The great light-house which crowns the tower. 2. The two projectors placed on the fourth platform. 3. The various lamps lighting different parts of the tower. Some people have irrevelantly compared the tower to a gigantic candle-stick, and the comparison is not altogether infelicitous. The establishment of a light of immense power at the very summit of the 300 meter column was obviously a necessity. The electric lamp is of the light-house type, with a dioptric drum of 23.62 inches diameter. The maximum of light is given at an angle of 40 degrees below the horizon, the apparatus throws the light to the horizon. Five catadioptric prisms extend the drum in its lower part; the object was to allow the beam to be seen at a distance of 1,500 meters from the foot of the tower, the prisms having been calculated in such a way as to project the light at an angle of about 12 degrees below the horizontal. This arrangement of prisms of so great divergence, which was really necessary on account of the altitude of the light, has been employed here for the first time, indeed, it would be without any object for ordinary purposes, as maritime light-houses throw the totality of their beams to the horizon. The flashes are obtained by means of vertical plano-convex lenses the full height of the apparatus.

From careful observations which have been made, the Eiffel Tower light is visible from the following places:—Chartres, 75 kilometers; Fontainebleau, 60 kilometers; Beauvais, 66 kilometers; Orleans, 112 kilometers. The lamp employed is an electric regulator of a mixed type, either automatic or worked by hand, fed by a current of 100 amperes and 70 volts. The colored flashes are produced by two colored glass screens placed in front of the vertical lenses. They succeed each other in the following order:—red flash, white flash, blue flash, fixed white beam, etc.

Two projectors placed on the Eiffel Tower below the platform of the great signal, supply the means by which the two long rays of electric light, now so familiar to every one in Paris, are thrown toward the horizon. These projectors are on a system devised by the late Colonel Mangin. The mirror which bears his name has two spherical surfaces—exterior and interior—of which the degrees of curvature were carefully calculated, taking into account the index of refraction of glass, in such a way that the reflected or refracted rays are projected parallel to the axis of the mirror. A special feature in their construction is, that they can be inclined so as to project the beam at an angle of 45 degrees to light objects close by. Under favorable conditions of observation and by means of a good night glass, it is possible to distinguish the details of objects lighted by the beam at a distance of four or five miles. The production of the glass was entrusted to the St. Gobain works, and it was only after many failures that the great blocks was obtained without air bubbles, cracks or other faults.

The small electric installation that furnishes the current to the light-house lamp, the projectors and the incandescent lamps, is placed in the southern pier of the tower. A Piloy two-cylinder compound engine of 70 h. p. furnishes the power. The total value of the current available for the tower is 1,200 amperes. Leaving the Eiffel Tower, one passes other points of interest, arrives at Machinery Hall and makes at once for the United States section. This occupies 40,000 square feet, Great Britain occupies 71,175 square feet, and the little nation of Belgium, 50,000 square feet. The exhibit of the Edison company occupies the entire frontage of the United States section, and covers 9,000 square feet with 50 feet frontage on the main isle, and fronts on four aisles, the largest single exhibit in the whole exposition. Mr. Hammer, the organizer and manager of this display, is an agreeable and affable gentleman, and has the thanks of the writer for his courtesy and attention. The Edison exhibit is devised to illustrate in miniature the experiments and practical results of Mr. Edison's inventions. For instance, the Edison lighting in New York is shown by subways seen in the flooring, with charts and appliances showing the method of distributing the lamps and supplying the current. The series of devices shown by Mr. Edi-

factor in the development of the industry. As is the prosperity of the users of service, so will be the prosperity of the suppliers of service.

Electric industry has been born and carried to its present state of development within one decade. This is evidence of the marvelous skill and honesty of manufacturers, operators and users. The value of this testimony is enormous. It is proof of an average intelligence, a reliability of character and workmanship, far superior to the attainments of any other generation. It furnishes a reliable foundation, on which future development can securely rest. It is the prophecy of the accomplishment of results, such as have never before blessed any age.

THE VALUE OF ELECTRICAL AND MECHANICAL DATA TO MANUFACTURERS.

A long list of electrical and mechanical apparatus is assembled and used as one machine, in the construction and operation of a composite central station. Every manufacturer of each part of this apparatus is vitally interested in knowing the exact truth regarding the performance of his specialty, under the widely varying conditions found in the practical operation of a large number of central stations. It is to his interest that he should claim for his specialty all the advantages it is capable of developing, and no more. The profit on a sale made on the basis of guarantees that cannot be realized, is a disastrous loss.

Inventors, designers, and manufacturers use their best efforts to supply a piece of apparatus that shall be the best for its purpose and price. They take careful note of all obtainable experience, and then attempt to take one step in advance by making an improvement. They are based on tests made in laboratory or shop, where their apparatus is handled by experts under favoring circumstances. The value of improvement depends upon its advantages proven by the tests of practical use when operated by persons representing all degrees of skill, under the widely varying conditions found in a large number of central stations. If it is necessary to take careful note of past experiences, and to keep a careful record of the data of performance during construction, is it not much more necessary to keep a careful record of the data of performance when in practical use? With such a record for a guide, manufacturers and buyers can feel an assurance of certainty in their transactions. This, however, is not the most valuable consideration. Those who accustom themselves to keeping properly systematized central station records, for the purpose of testing the claims of manufacturers of electrical and mechanical apparatus, will become good observers. More often than otherwise, they can suggest some simple change in the apparatus which will enable the manufacturer to fully realize his expectations.

In fact, it may often be found that the manufacturer has claimed too little, instead of too much, for his improvement. If he can secure proper data from the operators of a large number of central stations, he can remodel his claim as well as his apparatus in the light of recorded experience. This will make an enormous gain for him. It will enable him to base his business on a firm foundation not otherwise obtainable.

THE VALUE OF OPERATING, MAINTENANCE AND ADMINISTRATION DATA TO CENTRAL STATION COMPANIES.

Electrical and mechanical data are but one feature of the record upon which the success of central station companies depends. To complete the circuit, records must be kept of the data pertaining to all details of operation, maintenance and administration.

No manager can be equally competent in all departments. Unassisted he cannot observe all the details of the wonderfully complex business assembled in the operation of a composite central station. Upon the keeping of systematic records by his employés depends the ease of his position and the efficiency of his management. The value of a properly devised system of records of the daily operation of a central station can hardly be overestimated

A manager may regard many items in his accounts as reasonable, representing the best that can be done, which, when compared with the accounts of some other manager, whose genius or experience has directed his attention especially to such items, will appear entirely out of the way. No better guide can be found, to where improvement is possible, than such comparisons. The value of the comparison increases in ratio to the number of accounts with which it is made. It is, therefore, to the interest of every central station company to do all in its power to induce every similar company to be represented in an organization through which the desired data can be made available to each.

While managers of central station companies can render service of undoubted value to manufacturers by keeping truthful records of electrical and mechanical data, manufacturers can repay managers *in kind* by suggesting improvements in their methods of operating their plants. A manager is isolated. He can observe his own work and methods only. The representatives of manufacturers are everywhere. They observe the work of all managers and are quick to detect the methods of those under whose management their particular specialty produces the best results. Having found this, it is to their interest to communicate the information to every user of such apparatus. Thus, by each manufacturer looking after his own interest, each manager will receive the educational benefit of the experience of all managers pertaining to every detail of the apparatus under his control.

By means of the comparisons indicated, covering all electrical and mechanical data and all items of expense and income, any manager will be able to show to his directors how the results of the business he is doing for them compares with the results of all similar undertakings. It will give him the ability to indicate to them unerringly, what changes, if any, must be made in their policy or plant, to enable them to realize the best obtainable results. In furnishing the evidence obtained from the history of his own experience, each manager receives in equal exchange the record of experience of all others. He must be an expert and a wise man who can claim that he will not be a large gainer by such a transaction.

No more pertinent illustration of the value of systematic and organized effort to improve a special feature of the electric industry, can be required than that which is found in the work of the New England Electric Exchange. If the well devised system that has been developed by the workers in that special field can be adopted by the National Electric Light Association as one of its features, that fact alone ought to be sufficient to secure it a membership from every central station company in this country.

THE VALUE OF DATA TO THE USERS OF ELECTRIC SERVICE.

The advantages of electric service are not wholly under the control of manufacturers of apparatus, nor of the owners of central stations. Their development depends largely on the public policy of the community in which the service is rendered. If that policy places unnecessary restrictions on the business of the central station company, imposes on it methods of construction having no foundation in engineering requirements, nor in true considerations for the public safety or convenience; or, if it holds over the company an eternal menace by being willing to grant a franchise to a raiding enterprise, under the mistaken idea that prices can be permanently cheapened by competition, it will pay a righteous tax for its mistakes in the price of the service it uses.

A comparison of the results of such a policy, with that of a community that intelligently permits construction in accordance with the best engineering requirements and true consideration for the public safety and convenience; that sets itself as firmly against an ordinance permitting competition as it would a declaration of war, cannot fail to educate all users of service to a correct understanding of true economic conditions.

In the competition between cities, states and nations, the utilization of the discoveries of science in accord with the requirements of natural economic law, is a more potent factor in securing industrial supremacy than the possession of natural advantages. The day has come when intelligence is master of physical forces. When these truths are properly understood the users of electric service will demand and enact economic legislation that will secure the interests of the manufacturers of apparatus, the suppliers and the users of electric service, on terms that will enable each to realize the highest economic advantages that can be derived from the perfect development of the electric industry. The advantages of a public opinion so educated should not fail to cause all who can to unite in securing the data on which it must be based.

THE VALUE OF DATA TO INVESTORS IN ELECTRIC STOCKS AND BONDS.

A central station company must be organized under the state law. It must operate under a municipal franchise. From its birth, through all its existence it must be subject to the regulation and control of state and municipal legislation. This fact should secure for its stocks and bonds a financial standing equal to that of the best securities in the world. That they are not so held is evidence that there is a lack of data regarding them, and an unwise or unsettled condition of public policy regarding the tenure of their occupation of the field of their operations.

In my opinion, the exercise of state authority for the regulation and control of companies organized under state laws to operate under municipal franchises, should be so used as to render their securities as safe and profitable an investment as are the securities of national banks. Both are creations of legislative enactment. Both supply fundamental wants of industrial life. A calamity that would render users of *heat, power and light* incapable of paying their bills for service rendered, would render them incapable of paying their bank obligations. Organized to supply necessities of civilized life, based upon the prosperity of the communities in which they are located, guaranteed by the ability of users to pay for a service that secures them an industrial advantage, there is no economic reason why the securities of central station companies should not be a favorite investment for all who desire *permanency, safety and profit*.

Large investors require the greatest certainty and accept the smallest return for the use of their capital. All data and all legislation that tends to secure safety and permanency of invest-

ment, will tend to make capital abundant and cheap for central station companies, and thus enable them to reduce the cost of their service to its users.

Government will confer its greatest benefit on society when it renders investments in those enterprises which daily supply the necessities, comforts and refinements of life the best securities in the market. This done, capital, the sinews of peace as well as of war, will flow to such enterprises in abundant supply, and humanity will realize a condition of civilization such as the world has never yet enjoyed.

THE VALUE OF DATA COLLECTED BY GOVERNMENT AUTHORITY.

Every 10 years, under direction of the national government, a census is taken. The history of the development of the national census among all peoples is the history of their appreciation of the value of data. From the mere enumeration of men able to bear arms, census taking has broadened until it includes all data having a social or industrial interest.

The census of 1880 has no section for the industry of generating and distributing from central stations electric service for the uses of light and power. The census of 1890 should have such a section. If the data for it are properly collated and arranged it will make a marvelous exhibition of the birth and growth of an industry in the short space of one decade. The annals of civilization may be searched in vain for a parallel to it.

The data so acquired and published by authority of the national government, will give an impetus to all electric central station service, that will cause the record of the decade from 1890 to 1900, to be one of the transformations of methods of generating and distributing the means of supplying cities and towns with *heat, power and light.*

In 1900 the electric light will be the light of the present, the operating of street cars by horses will be unknown, and physical labor for man or woman in all industrial and domestic occupations will be reduced to a lower minimum than has ever yet been realized.

THE TRUE BASIS FOR THE WORK AND INFLUENCE OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

None of the results indicated can be obtained, desirable as they may be, unless they are the results of system and organization.

That records may be kept regarding pertinent points only, and with the least work or cost; that the data may be so tabulated that it can be readily understood and compared—a uniform system of records and accounts must be devised, covering all points of interest. To devise such a system and institute proper comparisons for the use and benefit of all central station companies, is the direct and most important work of this association. By doing this, it will furnish a reason for all central station companies to be represented in its membership. Such a membership will give to its deliberations and actions an influence that will have all the binding force of law in some directions, and in other particulars it will so direct public opinion that laws will be shaped in accordance with its views.

It will establish the electrical and mechanical value of all apparatus. It will develop the operation of central stations into the best organized and most reliable service in the country. It will secure the highest possible degree of economy, and the most reliable returns for invested capital that can be found in any industry. In doing this, it will be a large contributor to the material prosperity of the people.

The work and influence of the National Electric Light Association must begin in data, they must be sustained by data, they must have for their objective point the securing of data.

Mr. Foote—Mr. President, to give practical effect to my paper, I respectfully submit the following for the action of the association :—

WHEREAS, It is desirable that this association shall collect for the use and benefit of its members complete and accurate data regarding all important details involved in installing, operating, maintaining and administering the plants and business of central station companies.

Resolved, That a committee of five be appointed by the president to report at the next convention of the association forms and a system of records and accounts to be kept by central station companies, a system for reporting the same to the association and for comparing and publishing the data so secured for the use and benefit of the members of the association.

The motion was seconded by Mr. Brown.

DISCUSSION.

Mr. J. F. Morrison—Mr. Foote is engaged in a work that almost every one has neglected, and without which we shall never be able to conduct the electric business successfully. If you can once get to the point where men will come into this association, and state in plain terms their plans and their methods and the result accomplished, then you will have gotten to the point where the original idea of the National Electric Light Association can be carried out. Mr. Foote is on that track. I believe I am doing him scant justice when I say that he has spent more time and more money in the service of the association, during the past 12 months, than any man in it. I think that such work should be appreciated. I believe it will be appreciated, and I think in the end appreciated in a substantial manner to Mr. Foote.

Mr. Foote's resolution was here adopted.

Mr. R. L. Morris, of Nashville—The meetings of this association have been unsatisfactory to me. I have come and my manager and my superintendent have come. We go away not feeling that we have got what we came for. What we wanted was new points, practical points. We have come here and heard a great many theories upon electric light matters, but that was not what we wanted. Mr. Foote's paper seems to me striking out in the right direction—to get at the practical, to get at things that will benefit local electric light men. That is what I am here for. While it is hardly practicable to get the data that resolution calls for, and while I believe very few companies will disclose their private business, yet perhaps they will be willing to tell us something about the operation of their machinery, and what are their results. If I am asked what is the best lamp I don't hesitate to say.

Mr. A. J. De Camp, of Philadelphia—Mr. Foote has made suggestions which will bear looking into closely. There is a sealed book existing among the electric light people, and the resolution that has been offered proposes to open it. I know of companies that are deceiving themselves both ways. Some are deceiving themselves with the idea that they are making more money than they really are ; they think they are making money when they are really not making a dollar. There are others that think they are making nothing when they are doing very handsomely. It is my misfortune to be interested in companies of both characters ; it is a very unfortunate position to be in. I have had to stand up and make statements and rely upon my word being accepted, upon matters in which my statement was the only evidence I had to offer of their truth ; I mean abstruse subjects, and matters on which they were entirely skeptical. They had only my say-so, and if they were skeptical on the first statements I made, they were skeptical on the second. But if we had matters in this association in such shape as contemplated by this resolution, every manager of a company would feel very much stronger ; he could present his business to his board of direction with a good deal more force. I appreciate that it is a very difficult subject to deal with, but still, I do think that that can be got in such shape that a report can be made without revealing the private affairs of any particular company. I think that is entirely possible ; but the greatest difficulty is to get the companies to appreciate it, because it is going to involve the complete changing of the systems of some of the companies. It is true that a great many do not have any particular system. I have known cases of that kind ; but still they think they have, and they are going to be required to change them very radically, and that is going to be the difficulty in carrying that resolution into effect. But there is no doubt that there is a great deal of information that is needed among the electric companies. This is going a good way, to say that people do not understand their own business, but there are some things about my own business that in a self-satisfied way I think I understand ; but at the same time, down at the bottom of it, I am very doubtful myself.

Mr. H. F. Coggeshall—As it was stated that this paper would be on economic data, I was in hopes that the gentleman had discovered a method by which he could show me how to run an electric light plant, and make money out of it. Of course, the plant I have (as operated by the old company) was put up in a way that it was impossible to make any money, and we are now erecting a new station ; but I do not see any difficulty at all in getting information, without detriment to any company at all ; data, for instance, in relation to the coal, the kind of wire used, the durability of the circuit, and various other matters that would be profitable to every member of this association. I belong to the gas fraternity, and I have always attended every meeting, and when I found any one else doing any better than I was, it only set me to work to come up to it. That has been my point, and I am satisfied that there can be money made in the electric light business. These statistics, as far as we have got any in the state of Massachusetts last year, from 75 or 80 companies, showed that there were only five that carried a debit to profit and loss account, so that the whole thing depends upon the commercial value of running an electric plant, and it is the data that we want to be guided by regarding their operation.

Further remarks were made by Messrs. Whipple, De Camp, Morris, Morrison and the president.

Mr. M. D. Law, of Philadelphia, then read the following paper on

THE PERFECT ARC CENTRAL STATION.

(Abstract.)

The first station for central lighting started in San Francisco, was in a blacksmith's shop, using an old, worn-out, portable engine and boiler. The force consisted of one man, who was superintendent, dynamo man, engineer, fireman, trimmer, inspector and lineman ; but the price received for the lights would gladden the hearts of the electric light companies of to-day ; they were $10 per week, per lamp, and burned from dusk to midnight,

except Sundays. And when I look back to that time of running arc lamps on one wire, with ground return, I am amazed that there were so few troubles in the shape of grounds and fires. Not only was a ground return used, but inside wiring was thought good enough when put up without any insulation, fastened with staples. There are many places now, where bare wires are stapled fast, showing the absolute need of good, competent fearless inspectors, who will examine every inch of wire in a building, and not be afraid to condemn it unless it come up to the requirements of safety. All inside wiring should be inspected at least once a month.

An electric lighting station should be located as near the centre of the territory to be lighted as possible, but if sufficient ground cannot be obtained at a reasonable cost, it is better to go a little to one side rather than be crowded.

An electric lighting station should be built of brick or stone, in a substantial manner, not more than two stories high, and be as nearly fire-proof as possible. One of the important factors of such a station is good ventilation.

BOILER ROOMS AND BOILERS.

The boiler room should be located on the ground floor, with plenty of ventilation, making the fire room cool and comfortable. Everything being in full view and easy of access, can be kept clean and in order. In constructing an electric light station, the dynamos and engines are generally placed first, and what room is left the boilers are thrown into, without much regard to their economical handling. It is better to have a comfortable fire room, as the firemen can then remain by the boilers, doing justice to their work. With boilers in cellars, cramped, or poorly lighted and ventilated places, the men get careless, and the life of the boilers by corrosion and improper care is shortened.

It is found that two-thirds of the steam which is generated in a tubular boiler is made on the shell, and not in the boiler tubes, as supposed. In taking the heating surface of boiler tubes we should only take one-half the circumference, as the flame only impinges on the upper half of the tubes. With proper setting, flame can be carried the full length of a 30-foot boiler, with ordinary natural draught, using secondary combustion.

For a 1,000-light station there should be 12 single tubular boilers, 48 inches in diameter and 20 feet long, with 22 five-inch tubes, the shell to be made of three-eighth inch steel or iron, having a tensile strength of 55,000 pounds and 25 per cent. ductility in eight inches. Double rivetted longitudinal seams and first-class workmanship will stand a safe working pressure of 130 pounds per square inch, which will give 1,325 h. p. With the Corliss type of engine carrying 110 pounds per square inch, there would therefore be three boilers, which could be held in reserve, that being none too many for safety, and the other nine boilers can be worked very easily, as rapid combustion is the most economical.

ENGINES.

Electric lighting is one of the hardest kinds of work for a steam engine, the continuous running and the work being thrown on and off instantaneously causing immense strains.

There should be twin engines, connected at right angles, by which we have steadier power than with single engines, because we have the impulse of the steam at every quarter of a revolution. They should be built specially and have a larger amount of iron in all their parts than is used in an ordinary commercial engine, so that in times of trouble they can be forced for a short time beyond their ordinary load.

For a 1,000-light station there should be two 23 x 48-inch twin engines, running at a speed of from 70 to 80 revolutions. With this number and size of engines there will be a reserve of one engine, as the three engines will easily carry the load of 1,000 lights with economy.

It is settled that the Corliss type of non-condensing engines, properly constructed and handled, is the most economical, using less than two and one-half pounds of coal per horse-power hour, working at 110 to 115 pounds of steam. High speed is unnecessary; but a steady and uniform speed is required. An engine running forty revolutions per minute, provided the speed is regular, will make as good lights as one running 300 revolutions. It has been demonstrated in a great many plants using small, high speed engines, that this is true, while the cost for repairs with low speed is much less. On a pair of Corliss engines 23 x 48 inches, at 75 revolutions per minute, running day and night for nearly seven years, the actual cost for repairs was but $25, and during that time they were shut down but once on account of breakage, and then only ten minutes to disconnect one engine, the other being run with the load of both at increased steam pressure. The only argument against large engines is that in case of breakage it stops the whole plant, whereas in a series of small engines, connected direct, it will stop but one dynamo.

SHAFTING.

In all cases shafting should be made of hammered iron, and for a 1,000-light station the main line should be 75 feet long and 6 inches in diameter, and about 55 feet of countershaft, commencing at 5 inches diameter and reducing one-half an inch for every two machines, to be located on the ground floor, with pedestals as low as possible and bearings of cast iron, not less than four to one. The main bearings ought to be of phosphor bronze, and the shafting run not less than 300 revolutions per minute. The expense of oil on such a shaft, with proper appliances, will not be over $3 per year.

The driven pulleys from the engines should be on the ends of the main line shaft, with a clutch cut-off between one engine and the first dynamo pulley, one between the last dynamo and counter pulley, and one between the counter pulley and the other engine, with a clutch on the counter pulley. This will give perfect control, and enable either one or both engines to be run as the load may require.

DYNAMOS.

The dynamo room should be directly over the shaft lines, so as to use inclined belts. The roof should be supported without posts, and be of such height that the dynamos or armatures can be hoisted and carried over the other machines.

The dynamos should be mounted on cast iron beds, left entirely open to allow perfect cleaning, as the life of dynamos depends very much upon their cleanliness. They should be placed in rows, with sufficient space between them to allow easy access to all parts.

If the roof cannot be made sufficiently strong to support the combined weight of dynamo and armature on a track, then a good substitute is a frame supported on large casters, with a track over the top, having on it a chain-geared trolley and a chain hoist. This will allow of the rapid lifting of the dynamo, and moving it to some other place. With this arrangement a three-ton machine may be moved and put in running order in thirty minutes, requiring but four men.

A cupola should be provided, not smaller than ten by thirty feet, and ten feet high, with window ventilators extending the full length of the two sides. With such a cupola, one is enabled to put the lines in good shape, as well as to carry off a large amount of heat. The wires should run to the switch-board from binding posts placed through the centre of the cupola, and all crossing of lines should be made at this point.

SWITCH-BOARD.

The switch-board should be placed in the middle of one side of the dynamo room, and four feet from the wall, and should be amply spacious. As it is impossible to keep all circuits up to the full capacity of the machine, it is well to have a number of small circuits to couple in, in order to build up to a full machine capacity.

The line wires should come into spring jacks, arranged in two rows, with one side of the circuit on top and the other below, with eight inches of space between them, so that there is no possible danger of touching or short circuiting two of them. Before attaching to the spring jack, one side of the circuit should pass through an indicator for showing the direction of the current. The wires from the dynamos should be run beneath the floor, coming up on the back of the switch-board, and entering binding posts, to which a flexible cable should be attached, having a wooden-handled plug for entering the spring jack; these cables should be of sufficient length to reach either end of the switch-board. The spring jacks and binding posts of the machine cable should be so arranged that a connection cable can be hooked on for the purpose of moving the machine cable from one circuit to another, to cut circuits out or in without extinguishing the lights.

LINES.

Lines in all cases should be supported on glass or porcelain throughout their whole length, and should never enter a building without passing through hard rubber tubing with water drips on the outside. In all cases, inside wires should be run on glass or porcelain insulators; moldings or cleats should never be used for arc light wires, and in no case should they be put under floors or out of sight. All lines should be tested for grounds at least three times during the day and once every hour while the lights are burning.

STORE ROOM.

The store room should be of good size and provided with cupboards, drawers and shelves, that a full line of supplies can be kept on hand and issued only on requisitions from foreman of construction gang. When a job is completed a return should be made of the material returned, and the charge entered in the proper books.

A carbon book should be kept in which each trimmer signs a receipt for the carbons issued each day, as the trimmer reports each day the number of carbons used on his route. The stumps returned must accord with the report at the end of the week; he must account for the number of carbons on hand or pay for them. The trimmer will only pay for one lot of lost or broken carbons, as he finds it easier to take care of carbons than to buy them.

DISCUSSION.

Mr. Morrison—Is it possible that you ran your engine for seven years?

Mr. Law—Yes. They were stopped about an hour each morning and on Sundays.

Mr. Morrison—It is a very remarkable performance. Have you been familiar with any other engines than the Corliss?

Mr. Law—Yes, with the Porter-Allen and the Buckeye, about 100 horse-power.

Mr. T. C. Smith—Mr. Law states that the engines have only cost $25 for repairs. I would like to ask if the engineers, when the engines were shut down, have not done a good deal of fixing up, keying up, putting in packing, etc., which has not been charged up. I understand Mr. Law has a first-class mechanical engineer, whose advice or time ought to be charged to these engines. I am very well satisfied that engines of that type cannot be kept up to such a remarkably good record—as I know these engines have—without care of any kind. The $25 that he counts for repairs, I presume, are outside repairs, for a new set of brasses or something of that kind. We had one, 24 x 28, that cost us $1,000 for eleven months' run.

Mr. Morrison—We have some Corliss engines, and while they are good, their result is nothing like this. We have quite a large lot of Buckeyes which give excellent satisfaction. We have also Ball engines, tip top engines, giving the very best of satisfaction, and costing very little for repairs. But they have stopped several times in the last six or seven years. The Corliss engines are the worst of the lot.

Mr. S. S. Leonard, of Minneapolis—I would like to state in behalf of the Corliss engines, that we have been using one for nearly five years. It ran continuously for four weeks, and outside of packing, which everybody knows will wear out more or less, has not cost more than $25 for repairs.

Mr. A. J. De Camp—I think Mr. Morrison is right in saying we want facts. Now, facts are sometimes deceptive, unless we understand thoroughly all the conditions which surround the facts. It is true that the pair of Corliss engines referred to by Mr. Law did run seven years. They ran continuously—we had nothing else to run—for an average of twenty-two hours a day the year around with the exception of Sundays, when they shut down in the morning and started up in the afternoon. They rested eight hours on Sunday. What Mr. Law means in his statement is this:—Not that we did not incur the expense of having them well taken care of, nor that they were not subject to a certain amount of wear and tear. When he says $25, he is outside of the mark. That $25 grew out of the breaking of a dash-pot rod. The foundations of those engines cost, I think, about $2,600 or $2,700,

The success of these engines is due to the fact that they were well built in the first place, well bedded, and that they have had good care, for which we have had to pay.

Mr. Smith—Then you do not consider that it is due to the fact of their being Corliss engines at all?

Mr. De Camp—Well, I am a Corliss engine man. I do believe this,—that you want a Corliss engine in the hands of a Corliss man. That is certain, and they have said to me: "You must have a man to run a Corliss engine who understands a Corliss engine, who is in love with a Corliss engine." We have two Buckeye engines, 18 x 36. They were run just as long as they would run. When the time came, they made a bad break. When I take a given number of dynamos and run them on one type of engine, and they consume a certain amount of coal, if I shift them on to another type of engine, and everything else being perfectly equal, they use an excessive amount of coal; the one using the smallest amount of coal I call the most economical engine. We ran Porter-Allen's one season, and then put in Corliss engines. It was necessary to run the Porter-Allen's hard, and we had the old type of Brush 40-light machine. They did their work well at 285 revolutions, 100 pounds of steam. Now, Brush improved the dynamo to a 60-light machine. That was more of a load than the engine was equal to. We could never run more than 50 lights successfully, and did that by speeding the machine to 300 and carrying the same amount of pressure. We found out that there was economy in the Corliss engine, and that was the reason for dispensing with the Porter-Allen and substituting a Corliss, or some other larger engine.

The President—I announce the following committee on the World's Fair:—Dr. Otto A. Moses, of New York, chairman; E. T. Lynch, Jr., C. J. Field, Fred Gilbert and J. F. Morrison, assistants. As a committee on electrical statistics, the Chair would announce Mr. A. R. Foote, of Cincinnati, chairman; A. J. De Camp, of Philadelphia; S. A. Duncan, of Pittsburgh; E. F. Peck, of Brooklyn; S. S. Leonard, Minneapolis.

The convention then adjourned until 10 o'clock Wednesday morning.

WEDNESDAY MORNING SESSION.

The secretary and treasurer presented the following report:—

REPORT OF TREASURER AND SECRETARY.

NEW YORK, July 31, 1889.

RECEIPTS AND DISBURSEMENTS.

Cash balance from last report	$3,003 82
Dues received from 76 members	1,520 00
Sale of printed matter	2 00
Received from ex-treasurer W. H. Harding	299 73
Total receipts since la·t report	4,825 55
Expenditures as per accompanying vouchers approved by the Executive Committee	3,728 62
Balance, cash on hand	1,099 93
	$4,825 55

The present indebtedness is $259.60, which is a part of the funds advanced to the association by ex-president S. A. Duncan.

The expenditures since the last report may be classified as follows:—

Bills incurred previous to the Chicago convention	$1,483 82
Salary of secretary and treasurer, six months	999 96
Clerk hire, month of February	40 00
Postage	127 96
Stationery and printing (not including the official proceedings)	234 08
Printing the official proceedings	334 26
Official stenographic report of Chicago convention	161 25
Rent of office	157 50
Advertising in electrical journals	55 00
Expenditures not specified above	184 84
	$3,728 62

It will be noted from the official record of the New York convention that the account of the ex-treasurer called for a cash balance of $1,935.23, whereas the present treasurer has received only $299.73.

The treasurer would here state that he has received from the executive committee vouchers covering the difference between the above amounts. He has also received from ex-treasurer Harding $34.25, which did not belong to the general funds of the association; but was donated by members to the committee on patent legislation. This sum has been turned over to the chairman of that committee.

MEMBERSHIP, INCOME AND EXPENSES.

The number of members in good and regular standing on February 19, 1889, as per official report accepted at the Chicago convention, was 175; new members since that date, 76; making a total membership at present of 251.

The membership of the association has increased during the last year 55 per cent.

It has increased in the last six months 30 per cent.

The annual income of the association is at present $5,020.

Its running expenses for the last six months were $2,241.80.

Mr. P. H. Alexander then presented a Report on Harmonizing Electrical and Insurance Interests.

After reading a number of letters from several insurance men, Mr. Alexander's report stated:—

"You will readily see that with proper work on your part, such as the examining and licensing of men employed to make electrical installations, encouraging thorough inspection of work done, harmonious action can be brought about.

The 876 circulars issued to electric light companies—circulars that were issued entirely in their interest, the publication of the result of the answers could only have the effect of putting money into their pockets—were, we are sorry to say, answered by but 241 companies; of these 241 companies 172 were insured, 69 were not insured. In many cases they state (where it is not stated the reasons are probably the same) that they carry no insurance because the rate of insurance was either too exorbitant or they could not get any insurance at all; and here we may say in extenuation of the lack of responses from several hundred companies, that they were probably not insured, or not seeing through the purport of our circular, did not think it worth while to reply.

The amount of insurance carried by the 172 insured companies reported was in the year ending April 1, 1888, $2,970,540, the premiums paid thereon amounting to $11,319.81. The losses collected during that year were $21,597.61, showing that year a gain to the insurance companies of $19,722.20, or 48 per cent. on the amount of money received. In the year following, the amount of insurance on central stations, as far as reported, was $3,099,473. The premium received on such amounts to $51,565.57. The loss during that year, however, amounted to only $11,000, leaving a good balance to the insurance companies. The decrease in the amount of losses shows also that great intelligence had been displayed in providing central stations and diminution of fire risks.

The total for the two years then has been:—Insurance, $6,170,013; premiums collected, $92,885.38; losses paid, $32,697.61. You will see that the losses amount to but 35.2 per cent. on the premiums paid. A very small amount indeed. An amount that

ought to reduce the premium on central stations fully one-half on their present rate.

The average amount of insurance on each station is $18,841.50.

The following interesting data were also obtained from the answers received by your committee out of the number of central stations responding to the circulars:—We find that two-thirds, or actually 66 per cent., were built of brick, 22 per cent. of wood, 7 per cent. of stone and 5 per cent. of material unknown.

Only 69 stations of the 234 were built expressly for electric lighting purposes and exclusively used for that purpose.

We also looked into the causes of the fires that have occurred, and find that 31.4 per cent. of the losses occurred by tramps setting fire to stables in proximity to stations; 28 per cent. spontaneous combustion; 8 per cent. crude oil for fuel; 1 per cent. wooden roofs over boiler; 2-10 per cent. lightning; 2-10 oil waste under engine-room floor; 2-10 per cent. sulphuric acid, and 31 per cent. causes unknown.

With a desire to diminish fire risks in central stations, the New England Insurance Exchange has issued a form of what they call a model electric light station and insuring such a station at a very low rate. They also note on their circular, however, the gradual increase of the insurance rate by any one or more deviations from the rules laid down for a model station as printed in their circular.

The rate of insurance for such standard stations is .... .75

Charges for deficiencies as follows:—.

1. Frame .... .10
2. Over two stories high; for third story (a basement will not be regarded as a story) .... .05
3. For each story above third 10
4. Shingle roof .... .05
5. Cornice (except as provided in "Standard") on exposed station .... .05
6. Sheathing, lathing and plaster, or any finish leaving concealed spaces, according to discretion, but not less than .... .15
7. Stairs or elevators inside (except as provided in "Standard") .... .10
8. Boilers and chimney (except as provided in "Standard") at discretion, but not less than .... .15
9. Without any of the fire protection as required in "Standard," at discretion, but not less than .... .50
   (If only partial "Standard" requirements as to fire protection, at discretion.)
10. If fire pails and water only, not less than .... .40

Electrical arrangements.

11. Dynamos, unless as required by "Standard" .... .25
12. Insulation, unless as required by "Standard," at discretion, but not less than .... .25
13. Conductors, if concealed, at discretion, but not less than .... .25
14. Conductors, if run under the floors, except as permitted by "Standard" .25
15. Switch-boards, unless as required by "Standard," at discretion, but not less than .... .50
16. Feeder equalizer boxes, unless as required by "Standard," at discretion, but not less than .... .50
17. Care and attendance, unless as required by "Standard" .... .25
18. Exposure, at discretion, but not less than .... .10
19. Other occupancy of station, at discretion, but not less than, ... .10

Insurance on dynamos must be specific, and rate to be 25 per cent. in excess of schedule.

In view of the information gathered, the committee would recommend that the National Electric Light Association form within its body an organization, having for its purpose the improvement of the electric services in general, the better education of the workmen engaged in the business of installing electric light and power plants, and the improvement of electric work generally.

The committee would especially recommend that examination boards be formed in the different districts composed of several states, where men seeking employment as dynamo tenders, wiring superintendents or others holding responsible positions in conjunction with electric light installing can be examined, and to whom can be issued by the organization a certificate of efficiency, stating the qualifications, and for what particular work the man possesses.

The committee would also recommend that members of this association pledge themselves to have all men in their present employ examined in the manner proposed, and not to employ any person hereafter not provided with such certificate. In doing this the confidence of the insurance people will be speedily restored, and they will see that the electric light interest is beginning to have pride in its own work, and is trying to live down the bad reputation certainly earned by some individuals in former electric installations. Respectfully submitted,

P. H. ALEXANDER, Chairman,
H. B. CRAM,
M. J. PERRY,
M. J. FRANCISCO,
S. E. BARTON,
Committee.

The privilege of the floor was then offered to the representatives of insurance interests present, and brief addresses were made by Mr. Boughton, Mr. Andrews, Mr. Ryan, and Mr. S. E. Barton, all directed to the promotion of such methods of construction and operation of electric plants as would encourage their insurance at lower rates.

After further discussion of the insurance question by Messrs. Barton, Francisco, Morris, and Lynch, a motion by Mr. Morris, seconded by Mr. Lynch, for the continuance of the committee, with instructions to formulate a plan for mutual insurance by electric light companies, was voted upon and adopted.

Mr. Charles A. Brown, of Chicago, then offered the following resolution:—

Resolved: That a committee of three be appointed by the president and instructed to prepare and present to the proper committee of Congress a petition on behalf of the National Electric Light Association for the abolition of the customs duty on copper ingot, wire, plates, sheets, bars and rods.

Mr. G. M. Phelps, of New York—I second the adoption of Mr. Brown's resolution.—

Mr. Morrison—If we could get Congress to adopt that I think that the work of the National Electric Light Association will have reached a point which will entitle it to the grateful remembrance of every citizen of this country who has its good at heart. I am delighted that it came from a gentleman from Chicago. I would be very glad if every gentleman engaged in other lines of business that impinge on our affairs would present a precisely similar case, and nothing would give me greater pleasure than to welcome Mr Brown and his colleagues into the ranks of the free traders.

Mr. Phelps—I am very glad that Mr. Morrison has preceded me with such a hearty commendation of the resolution. It does not seem to me at all certain, and, in fact, not very likely, that the adoption of this resolution would secure the abolition of the copper tariff next winter, but it would be a move in that direction. Those who have read attentively the public journals on the subject of the copper tariff may observe that even protectionist journals realize that this is a tariff which ought to go. It seems to me eminently proper that this body should memorialize Congress on the subject, in view of the immense proportion that copper bears to the cost of all electric plant. I have not at this time the precise figures on that point, but it is my impression that copper enters into the cost of electric plants in general to the extent of at least one-third, perhaps more. And whatever will reduce materially the cost of electric plants will indirectly, if not directly, increase your business, the business that the members of this association are engaged in. All are desirous of bringing the production of electric light down to as low a cost as possible, and the cost of the initial plant causes a very large proportion of the cost of production. Therefore, I have risen to second this resolution. It is a move toward the future prosperity of electrical interests, and we have good reasons for taking it up. The copper tariff is a useless tariff, and the copper men themselves say that they can make their copper for six or seven cents per pound; and while the present differences in price in this country and Europe are not greatly oppressive, we know what the price has been through the period of the combination that has been existing for several years. This tariff is a most powerful instrument in behalf of those who want to use it for speculation.

The President—I am a protectionist, but I believe first in protecting ourselves, and the resolution as offered by the gentleman from Chicago, it seems to me, is right in line of the protection of the electrical industries of this country. I think that we should protect ourselves, not only against our foreign cousins, but against our home friends and relatives, at certain times, and I think this is one of the times.

The president put the question and declared the resolution adopted, and appointed as the committee Messrs. Chas. A. Brown, of Chicago; G. M. Phelps, of New York; and J. F. Morrison, of Baltimore.

Mr. J. T. Henthorn then read a paper, by himself and Mr. C. R. Remington, on

THE NEW CENTRAL STATION OF THE NARRAGANSETT ELECTRIC LIGHTING CO., PROVIDENCE, R. I.

(Abstract.)

The vital practical problem ever present for consideration is how best to reduce the cost of the running expenses of a station; that is, how to increase the earnings returned to stockholders in the form of dividends. We have come to the conclusion that the most needed and radical improvements should bear directly upon the steam plant and the mechanism for transmitting the power to the dynamos. M. J. Perry, Esq., the general manager of the Narragansett Electric Lighting Co., of Providence, R. I., commissioned us to design and plan the arrangement of the entire motive power and machinery, as well as the buildings and chimney necessary to the completion of a proposed first-class electric lighting station, which might be expanded to an ultimate capacity of some 12,000 h. p.

The site for the new station is on the side of the Providence River. The lot comprises some 55,000 square feet of land, with a water front on one side. In the preliminary plan (which was afterwards adopted) the station was represented as having two dynamo buildings, each 60 feet by 200 feet, the number of dynamos to be provided for in each building being about 80, of an average capacity of 50 to 60 arc lights; the dynamo houses being united along one side end by a building used for offices, storehouses, etc. The dynamos are so arranged that a much greater number than usual are located in a given floor space. All

the dynamos in each building are driven direct from pulleys rigidly secured to a main line shaft located below the dynamo room floor. This arrangement forms a hollow square, open on one side. In the central space, covered by a well lighted and ventilated roof, are located the engines.

It was decided to adopt triple expansion compound engines, provided with independent surface condensers and circulating pumps, the initial steam pressure being 160 pounds. As the ground has a water frontage sufficient to allow vessels to lie alongside, it was decided to locate the boiler house on that side, the plan being to discharge the coal from the vessels directly into coal pockets built into the roof of the house, from which, by a series of suitably arranged chutes and pipes, the coal is delivered by gravity to the front of the boilers. The water-tube type of boiler was selected. To the rear of each battery of boilers is located, in the main flue, an economizer for increasing the temperature of the feed water. By means of short branch flues provided with dampers, the economizer may be cut out and waste gases pass to the chimney. The chimney is made sufficiently large to produce ample draught for the entire series of boilers. It is located near the boiler house, and extends through the engine house roof. The size of the flue itself is 14 feet in diameter, and it runs 235 feet above the engine room floor.

The buildings constructed thus far are a dynamo house 200 feet long and 60 feet wide, a boiler house 71 feet 10 inches wide inside, and 68 feet long, running lengthwise, which is of ample capacity to develop 4,000 h. p., and an engine house 57 feet wide

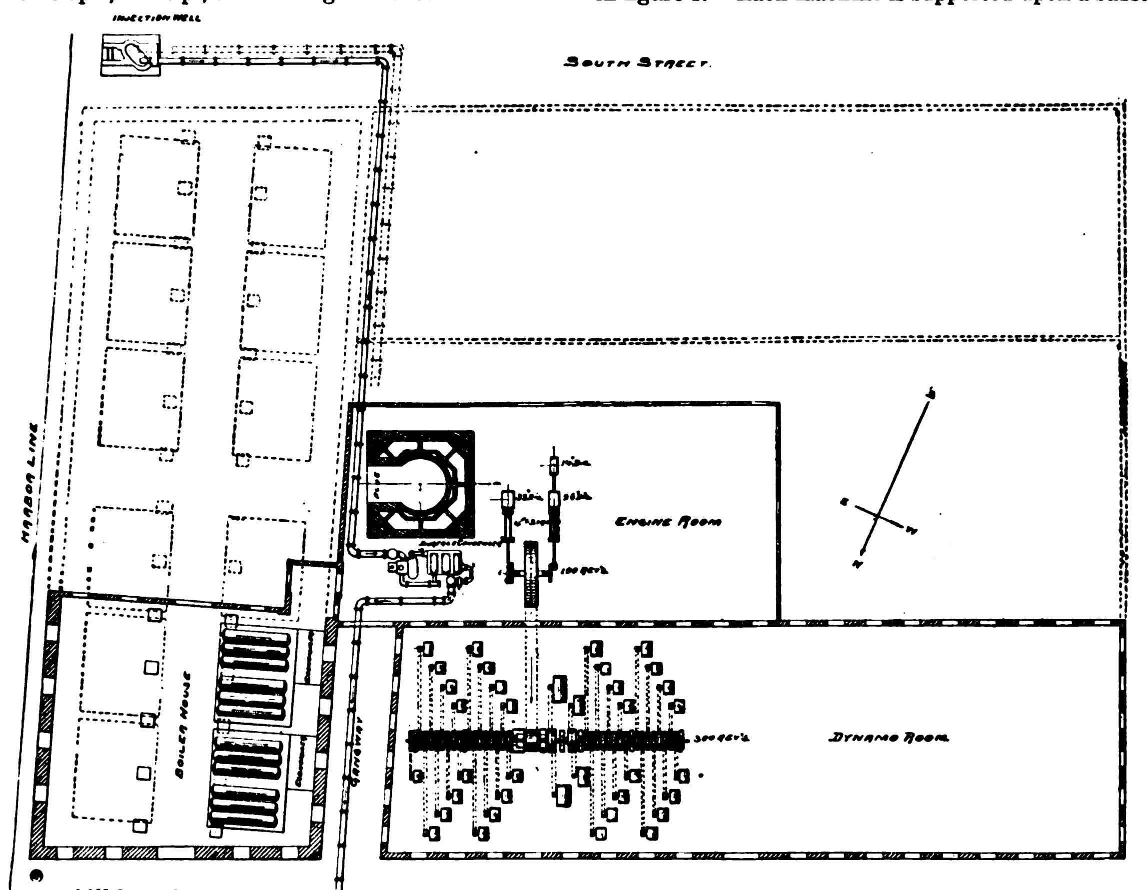


Fig. 1.—Plan of Narragansett Company's Station, Providence, R. I.

and 110 feet long. These structures are of brick, of plain design, having granite underpinning and may be considered practically fire-proof, as the only wood entering into their construction is that of the window frames and floor. The chimney, although not as yet finished, is 28 feet 6 inches square at the base, and 238 feet high from high water line.

The plans of these buildings are shown in figure 1 and are represented by full lines, while the dotted lines represent similar buildings to complete the plans in the future. It will, therefore, be seen that ample provisions for extension have been made, without interfering with daily operations or undoing what has been done.

DYNAMO HOUSE FOUNDATIONS.

The foundation which we had to deal with was a public dumping-ground, overlaying a strata of dock mud and blue clay, which was as unstable as oil; underlying this was sand, and finally hard pan at a depth varying from 35 to 50 feet. It was determined that piling should be driven, and the specifications for the dynamo house foundations were so drawn that piles of 30 feet in length, increasing toward the river to 45 feet in length, should be driven; and the whole, which were of spruce, and each being 11 inches diameter, were cut off 36 inches below high water. Upon hard pine pile caps was started the masonry wall, 4 feet 3 inches wide, tapering to 24 inches on the four-foot level above high water. This wall was laid in cement mortar in the proportion of one cement to two of sand.

DYNAMO HOUSE.

The walls of the dynamo house, which, as before stated, is 60 feet wide in the clear, and 200 feet long, are 20 inches thick from the foundation up to the level of the dynamo floor, about 7 feet 9 inches above the sidewalk; thence it is reduced in thickness by a pressed brick belt course to 16 inches, and carried up to the 29 feet 3 inch level, leaving 17 feet from the dynamo floor to the under side of the wrought-iron trusses, as shown in section in Figure 2. The house is covered by a wrought-iron truss roof. Upon the roof is a ventilator 8 feet wide and 5 feet high, running 170 feet longitudinally; to the sides of the ventilator are bolted double-glazed windows, so arranged as to be opened from below.

DYNAMOS.

In the general lay-out of the dynamos, provision has been made for placing four rows on each side of the centre line of the house. The dynamos are placed in echelon, in sections of four, as shown in figure 1. Each machine is supported upon a substantial brick foundation laid up with cement; the several 12-inch walls forming the foundations of each series are banded together, and, in fact, all built at one time, so that the foundation for one machine acts as a brace for its neighbor. Between these foundations and the walls of the building is a wooden floor of ordinary mill construction. Directly beneath each machine is left open a section of floor for a thorough ventilation of the armature. All of the dynamos are belted down through the floor to pulleys rigidly secured to the main shaft.

The ultimate capacity of this first dynamo house is about 80 machines of the ordinary 50 or 60 arc light size.

The dynamo room is thoroughly lighted on the sides and ends by large windows. The windows are placed 10 feet, centre to centre, and the sills 23 inches above the dynamo floor, sufficiently low to influence the ventilation.

CRANE.

Directly underneath each truss of the dynamo room, and bolted thereto, is built in each side wall a chair or casting for

supporting tracks for a traveling crane for moving the dynamos. The tracks are of 9-inch rolled beams, weighing 70 pounds per yard, and were cut in 20-feet lengths, the bottom flange being bolted to the cast-iron chair and the ends strapped together by a plate, and bolted.

ENGINE HOUSE.

The engine room, as now completed, is 57 feet wide and about 110 feet long, and covered by an iron truss roof. Below the floor is located the first leg of the 26-inch exhaust pipe, and above and supported upon the wrought-iron trusses is the 18-inch wrought-iron steam pipe. These two pipe lines will ultimately form a U-shape; that is, passing up one side of the room and returning down the other.

ENGINE.

The engine, which is of the triple-expansion type, was especially designed for the service of the station by E. Reynolds, general superintendent of E. P. Allis & Co., of Milwaukee, Wis. The high-pressure cylinder of the engine is 14 inches in diameter, the intermediate cylinder 25 inches in diameter, and the low-pressure cylinder 33 inches in diameter, each 48-inch stroke. The and for the large cylinder one eccentric is used to operate the two steam valves, and one for the two exhaust valves, the object and advantage of this arrangement being to obtain any amount of compression that may be found desirable, independent of the action of the steam valve.

The diameter of the main driving wheel is 17 feet, and of 45-inch face, made in segments, and carrying a 44-inch double belt made by Messrs. C. A. Schieren & Co., of New York.

The jackets of the two receivers and of the three steam cylinders are drained by a pump 3 inches in diameter and 5-inch stroke, operated from the condenser of the engine, the water being pumped into the feed-pipe.

The frame of the engine is one peculiar to the builders, and was first designed for heavy rolling mills, and consists of strong wrought-iron bars or rods running from the cylinder head to the pillow block. The rods tie these two parts together, and at the same time form a part of the guide-rod for the horizontal cross-head. From each cross-head extend two hammered iron piston-rods for the intermediate cylinder and large cylinder, and for the small cylinder one rod passes through the back head of the intermediate.

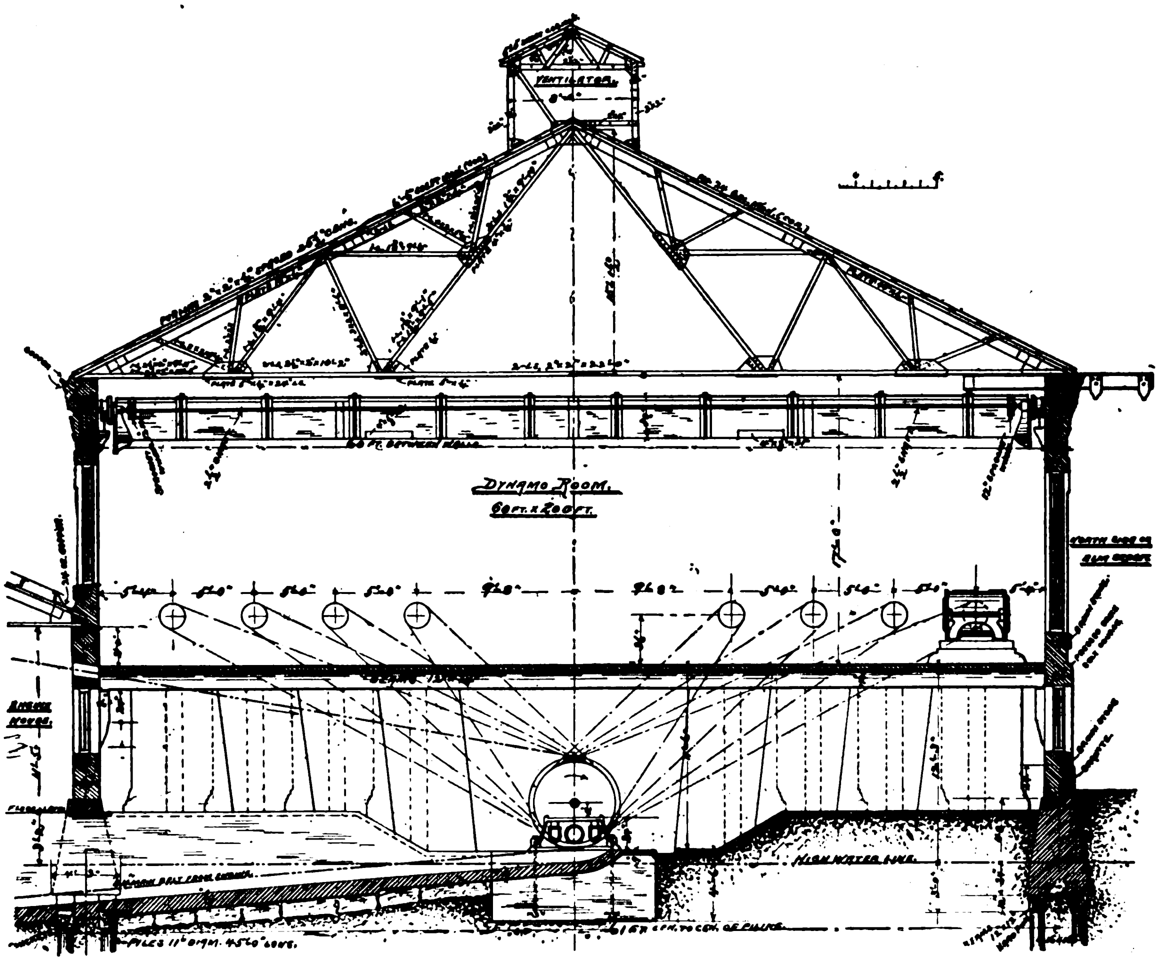


FIG. 2.—Cross-Section of Dynamo House—Narragansett Company's Station, Providence, R. I.

working barrels of each cylinder, together with the heads, are thoroughly jacketed with steam at boiler pressure, also the receiver between the high and intermediate cylinders; and that between the intermediate and low-pressure cylinders is likewise jacketed by steam at boiler pressure.

The valves of all the cylinders are located in the heads, and as the working faces of the valve with this construction are within a very short distance from the face of the heads, the waste clearances are reduced to a minimum. The valve gear is of the liberating type, the valves themselves closing by vacuum-pots located level with the engine room floor. The automatic cut-off mechanism of the first and intermediate cylinders are actuated by and under the control of the governor, and at the same time the point of cut-off of the intermediate cylinder may be set at a fixed point independent of the governor if it is so desired, while for the large cylinder the point of cut-off is fixed by hand adjustment and always independent of the action of the governor, and thus a perfect means is afforded to adjust the ratio of expansion relatively in each cylinder, and effect the greatest possible economy of steam, and consequently fuel. For the first and intermediate cylinders one eccentric is employed to operate their valve gear,

The speed of the engine is 100 revolutions per minute. To provide efficient lubrication for the main bearings, a positive oil circulation is produced by a pump operated from the valve-gear rocker shaft.

CONDENSER, ETC.

The condensing apparatus for the engines of the station will be arranged in series—*i. e.*, it will consist of several surface condensers and combined air and circulating pumps working upon one large exhaust main, which is common to all engines of the station. This plan was adopted, because any particular surface condenser, or a number of such, with its independent motive power for driving the pump of the same, can be operated at will, with the result of producing the desired vacuum upon the exhaust main. And as all of the engines are connected to this exhaust main, and are shut out at pleasure, therefore it follows that any individual engine is not restricted in its operation to the running of any condensing apparatus in the station.

Electric light stations, as we all know, are subject to wide variations in power during a period of twenty-four hours, and to economize power in the operation of air and circulating pumps

of the condensers, we have selected a cut-off engine as the motive power for the condensing apparatus; the point of cut-off of this engine being controlled by the vacuum in the surface condenser. As the load upon the main engines is increased, the natural tendency in the action of the surface condenser results in a decrease in the vacuum by a consequent rise in the temperature of the overflow water, due to the introduction of a larger volume of exhaust steam into the condenser. This decrease in vacuum immediately acts upon the cut-off mechanism of the engine of the condensing apparatus, and, by allowing the steam in the cylinder to follow farther upon the stroke before cutting off, the engine increases in speed, and thus delivers a greater volume of circulating water to the condenser, and at the same time correspondingly increases the volume of discharge from the air pumps. An opposite action results from a diminution of the load on the main engine, and correspondingly slows down the condensing engine.

The condensing apparatus engine is 12 inches diameter and 16 inches stroke, with liberating valve-gear, and of the same pattern as the large engine. The air and salt water circulating pumps are respectively 24 inches and 16 inches diameter, each of 16 inches stroke. Intermediate of the air and circulating pumps is located on the overhead crank shaft a plain fly-wheel 10 feet in diameter, the centre of the shaft being 10 feet 1 inch above the floor.

SHAFTING.

The engines are belted to jack pulleys secured upon open hearth cast-steel hollow shafts, through which freely passes and revolves the 6-inch hammered iron line shaft. On one end of the hollow shaft is cast a head 24 inches in diameter, and to which is bolted a 54-inch Hill friction clutch, to transmit the power of the first engine of 500 h. p. As the hollow steel shaft is supported in bearings 9 inches in diameter, and independent of the line shaft, it follows that the engine and its jack pulley, and, of course, the hollow shaft, can be stopped at pleasure by throwing out the friction clutch, and still allow the main line to revolve as usual, but without touching the inside surface of the hollow shaft. In case the main line is in operation, and it is required to start up any engine, it is merely necessary to put the engine in operation and throw in the friction clutch, and consequently connect the whole firmly together. Alongside of the clutch upon the end of the hollow shaft is still another, 60 inches in diameter and of 800 h. p. capacity. This clutch is arranged so that the main line may be cut out at pleasure at that point.

All of the bearings in which the shafting revolves are of liberal length, and provided with bronze ring oilers, some having three rings, while others have but two. These rings encircle the shaft and revolve by contact therewith, thereby carrying a large quantity of oil from a chamber, formed in the lower part of the pillow blocks, to the upper surface of the shafts, and thus provide ample lubrication, a feature very essential in view of the fact that the shafting is to run 300 revolutions per minute, and that the bearings, especially those of the hollow shafts, are of large diameter.

BOILER HOUSE.

The first section of the boiler house built is 68 feet long and 71 feet 10 inches wide, to accommodate four sections of boilers, and is so arranged that it may be lengthened the full width of the lot as required. There are two rows of columns running lengthwise with the building spaced 14 feet 8 inches, centre to centre, while across the house the centre lines of the two rows are 21 feet. Under each column are driven a cluster of 15 piles to a depth of 45 to 53 feet below high water, and upon these are built the cut granite piers for supporting the coal pocket. The walls of the house are 26 feet 1 inch above the floor, the first 5 feet 10 inches being 36 inches thick, with granite underpinning, and the balance of 32-inch wall. Lengthwise with the house is an ash tunnel four feet six inches wide and six feet four inches in the clear, in which is a tramway, and by means of a turn-table opposite each transverse tunnel leading directly underneath each boiler grate; the carts for collecting the ashes traverse back and forth as they become filled.

Directly over the boilers will be stored the fuel for the station in a wrought-iron coal pocket 25 feet in depth, and of a capacity for this first section of 2,500 tons. Being directly upon tide water, the coal is taken from the vessel alongside of the building, and is landed at once to any section of the pocket. The coal, after being weighed in a movable machine, is deposited opposite to the furnace doors by gravity, the floor of the pocket being built on an incline to facilitate the discharge of the coal.

BOILERS.

The first section of 500 h. p. boilers for the station were made by the National Water-Tube Boiler Co., of New Brunswick, N. J., and are, as the makers' name implies, of the water-tube type. They are set in two batteries to a section, each of which is of 250 h. p., upon the commercial basis of 30 pounds of water evaporating into dry steam per hour; and, as the engine is guaranteed to develop an indicated horse-power for 12.6 pounds of water per hour, the boilers will, therefore, evaporate water enough to develop by the engine about 1,100 h. p. per section.

Each boiler of the section is made up of 144 steel tubes four inches in diameter and 16 feet long, the tubes terminating into charcoal iron cast headers lying horizontally. These several layers of headers are nippled together with 4½ inch steel tubes, and are finally connected to the saddles by 5-inch nipples. Upon the top of each boiler of the section are placed three 36-inch steam and water drums, made up of 7-16 inch steel plate, to the lower side of which, at its extreme ends, are rivetted the up and down-take saddles which receive the end of the 5-inch rear down take tubes, and at the forward end the 5-inch nipples before described, which are expanded into the upper row of horizontal headers.

The length of the grates under each boiler is six feet, and the width of the furnace nine feet, and they were designed for the ultimate introduction of a mechanical stoker of some improved pattern when the next series of boilers are placed in position. Underneath each section of grates, and below the level of the boiler house floor, is a pit or tunnel, as before stated, in which is a tramway for conveying the ashes and cinders collected in a car provided for that purpose, and by means of a turn-table the car is transferred to the longitudinal pit or tunnel located at the centre of the boiler house, from whence it is propelled to the street, and finally hoisted by power into the cart for conveying it away.

The paper described at length many other interesting details of the station, and concluded as follows :—

In conclusion, we desire to place on record the fact that the development and phenomenal success of this company, which started but five years ago with 29 lights, and the inception of this new station, marking an advance in this field of engineering, is due to the broad and comprehensive labors and achievements of Marsden J. Perry, Esq., vice-president and general manager, a gentleman of sound business abilities, readily grasping engineering details, and fully appreciating the axiom that the "best is the cheapest" in the end.

WEDNESDAY AFTERNOON SESSION.

The convention was called to order at 2.30 P. M., by the president, who then introduced Mr. F. A. Wyman, of Boston, who delivered an address on The Constitutionality of Execution by Electricity. Mr. Wyman, who has made a close study of his subject, presented the results of his examinations of the statutes of several states, together with many judicial opinions touching the application of "unusual" or "cruel and unusual" punishments. He also reviewed the testimony taken before the referee recently in the Kemmler case in New York.

Concluding, Mr. Wyman said :—

"When the state brings forward men who testify to their belief that death by the electrical current is certain and painless, there arises a conflict of evidence. When experts disagree, who shall decide? In the testimony before the referee, and in the articles and discussions in newspapers and magazines, the preponderance of evidence has been that such punishment is cruel, or at least enough evidence of its cruelty has been given to raise a reasonable doubt in the mind of an ordinary man; enough surely to prevent humane and enlightened legislators in other states from adopting such means of punishment in the present age of uncertain knowledge of electricity, and enough to induce the legislators of New York to repeal their own law requiring such mode of punishment.

But the question now before us is whether the courts of New York will pronounce such punishment unconstitutional because "cruel and unusual," and not whether the law-making body of New York would, with all the evidence then before it which now exists, have refused to legalize such a cruel and unusual punishment. To enable the courts to declare that a statute is unconstitutional, its invalidity must be shown beyond a reasonable doubt. As the Supreme Court of Massachusetts said in Talbot *vs.* Hudson, 16 Gray, 422 :—"But it is to be borne in mind that in determining the question whether a statute is within the legitimate sphere of legislative action, it is the duty of courts to make all reasonable presumptions in favor of its validity. It is not to be supposed that the law-making power has transcended its authority, or committed, under form of law, a violation of individual rights. When an act has been passed with all the requisites necessary to give it the force of a binding statute, it must be regarded as valid, unless it can be clearly shown to be in conflict with the constitution. It is, therefore, incumbent on those who deny the validity of a statute to show that it is a plain and palpable violation of constitutional right. If they fail to do so, or leave room for a reasonable doubt upon the question whether it is an infringement of any of the guarantees secured by the constitution, the presumption in favor of the validity of the act must stand."—See also State *vs.* Lasater, 9 Bax., 587.

In the case of Kemmler there is, as I have before said, either a preponderance of evidence that punishment by the electrical current is cruel and unusual, or at least a reasonable doubt exists as to its non-cruelty; and in my opinion it can be said with truth that it has been proved *beyond a reasonable doubt* that it is cruel.

I have tried to show that the power to punish lies in the law-making bodies except so far as they are restrained by constitutional provisions; that cruel punishments are forbidden in some states, "cruel and unusual" in others, and "cruel or unusual" in others; to the history of such a restriction has been added the words of judges in construing it. My endeavor has been to show that punishment of death by means of the electrical current is so cruel that legislators ought not to adopt it, so cruel that the legislators of New York ought to repeal their law, and so cruel that the courts of New York ought to pronounce the statute unconstitutional."

DISCUSSION.

Dr. Moses—Mr. Wyman's view, I think, will ultimately prevail, and lead, as we hope, to a repeal of this very obnoxious law, whose discussion is now agitating our press and our people.

Two years ago, many of us received a communication from Mr. Elbridge T. Gerry, the noted philanthropist of New York, in which he requested some opinions or expression of views on a proposed law of killing by electricity. The law was put upon the statute books, but soon it became apparent that it was a hasty proceeding. We, meeting at our several conventions, were too much occupied with the useful and the practical side of our art to engage in any considerations of such a far-fetched use of electricity as killing. The result was that we allowed the law to go almost unnoticed upon the statute books, and when the time came for a criminal to be condemned, we found ourselves placed in that unenviable position of representing an interest the chief instrument of which was about to become a public executioner. By a sort of spontaneity of action protests were sent forward from all quarters. The first criminal who was condemned to death under the law has not yet been killed, but an effort has been made to prevent his death by electricity, and he is to-day in a most unfortunate position. Only recently, at Buffalo, the matter has been argued, after a prolonged hearing before a referee in New York, and an enormous amount of testimony of a very conflicting nature has been brought to bear. It is a sad thing that we have conflicting testimony, because the fact that certain experts gave their opinions *pro* and *con* as to the certainty of death has been taken by the press to convey the idea that an uncertainty has existed in the minds of those who use the current in great quantity as to the desirability of using it for killing purposes.

This action in New York and in Buffalo has led to a simultaneous desire on our part to bring this matter up at once for deliberation. In order to have accurate information for the convention a letter was addressed to every manager of a central station in the United States, to the number of 800, requesting him to reply to the following questions:—

Is there anyone in your employ, or of your acquaintance, who has received powerful shocks of electricity from a dynamo-electric machine?
What was the nature of the current, continuous or alternating?
What was the electromotive force of the current of the machine in volts?
What was its capacity on full load in amperes?
What amount of current is supposed to have passed through the person?
At what points on his body were the contacts made with the electrodes?
Can you say which was the positive pole, *i. e.*, where did the current enter?
Was the shock a painful one?
What were the sensations?
What were the effects and how long did they last?
Please give as many details of the accident as you can.

I have received replies from which I estimate that 73 accidents had happened in central stations. Of these, 19 were due to the alternating current, 54, to the continuous current. The questions that we asked bring out some very remarkable information, and I have this numerous list of answers collated here, open to members of the convention for inspection.

Now, gentlemen, an effort has been made, and a persistent one, to fill the public mind with horror at the mention of the word electricity. When I see that citizens of New York and all of our large cities to-day fear to touch a wire; that they pass hastily under an arc light wire stretched across the street; that they feel, as I have been told, that when introducing an electric wire into a house they may at any moment come in contact with the same instrument that is to deal death upon a criminal; when the public are educated to this, I say that such a state of feeling will result disastrously to our interests.

There is another thing that I would say; I do not see in this hall one face of one man who would venture to apply such a thing as an electric current for purposes of death. I doubt whether there is in this broad country one reputable electrical engineer who would deign to connect his name with the application of electricity to the purposes of public execution. Mr. Elbridge T. Gerry said that he had consulted physicians for the purpose of finding out whether prussic acid or morphine or strychnia or chloroform might not be used, and he met with the universal reply that not one physican could be found to administer any of these death-dealing agents. Shall we be placed in the position that one electrician can be found willing to administer our current for the death-dealing purpose? I deny that such a thing may be, and yet we hear that at this moment, while we are here in convention, there is one in the penitentiary at Auburn who is experimenting on animals preparatory to the administering of that current to the criminal Kemmler. I say let us here vigorously condemn that action.

We have in the case before us a law upon our statute books which is a most obnoxious one. Gentlemen, now is the time for us to call the attention of the authorities to the iniquity of this law; as being a barbarous practice; and interfering seriously with a rising industry. I would offer a resolution which embodies the views I have expressed.

WHEREAS, the law requiring the execution of criminals by electricity, enacted by the General Assembly of the State of New York, was enacted under a misapprehension of its philanthropic importance; and

WHEREAS, the National Electric Light Association regards such a law as an unnecessary degradation of the most useful natural agent that science has ever rendered available for the service of man; be it

Resolved, First, that the National Electric Light Association does hereby respectfully petition the General Assembly of the State of New York to repeal said law at its next session. Second, that in view of the inexpediency of said law, and until it is repealed, the Governor of the State of New York be requested to commute the sentences of all criminals condemned to be executed by electricity, to imprisonment for life. Third, that a copy of this preamble and resolution be forwarded at once by the secretary of the association to the Governor of the State of New York. Fourth, that the proper officers of this association and that the chairman of the committee on state and municipal legislation forward a copy to each member of the General Assembly of the State of New York, at its next session, together with copies of such papers as the committee may have at its disposal, urging the repeal of said law.

The resolution was seconded.

At the suggestion of Mr. C. R. Huntley, of Buffalo, Dr. Fell, of that city addressed the convention. Dr. Fell had made some experiments with electricity upon animals, and was one of the supporters of Mr. Gerry in recommending the electrical execution law. He expressed his conviction that death by electricity was less painful and more speedy than by hanging, but deplored any injurious reflection upon the useful applications of electricity.

Mr. Morrison—Dr. Fell, who do you think would be the best judges of the effect it would have upon the physician's practice, that body of men or some other body of men who did not use or know nothing about it? The physicians gathered together, and decided, as Mr. Pope suggested, that the use of any method in their practice as a means of execution would be detrimental to them. I ask you what body of men would be best qualified to judge as to what would be injurious to the practice of their profession as physicians?

Dr. Fell—The physicians.

Mr. Pope—Which has killed more people, gas or electricity? Is it not a fact that a week or two ago a new method for the destruction of animals was introduced in the City of New York, and that that was publicly mentioned in the papers as a more humane method of despatching dogs than the method heretofore prevailing?—that is, the introduction of gas in a sealed box.

Dr. Fell—Possibly the use of gas is painful during the first inhalation—very painful, indeed, until a man is asphyxiated—and gas would be more painful than electricity on account of the nerve current being so much less than the current of electricity.

Professor W. A. Anthony—I have only a word or two to say. In the first place, in regard to the velocity of electricity, Dr. Fell made the remark that it was well known that Wheatstone demonstrated that the velocity of electricity was 280,000 miles per second. All of us know that such experiments were unreliable, and that it is now perfectly well understood that it was not the velocity of electricity at all, but simply the time required for wires to be charged, and for a spark to leap across the gap between two wires. The velocity with which electricity passes over any given conductor is not known, and we know that that velocity depends upon many things. In the first place, it depends upon the conductivity of the conductor; in the second place, upon the amount of pressure or potential; and upon many other things. The fact is that in the nerves of the human body the velocity of the electrical current is known to be immensely less than it is in a metallic wire. In a wet string, the velocity of the current in passing over even a space of a few feet is readily measurable, requiring quite a large fraction of a second to pass over a distance of even a few feet. I merely speak of this matter that it may go upon record, if these discussions are to be reported, that this question of the velocity of electricity cannot settle the point as to whether death by electricity is painless. A word in regard to another point. An execution of the death penalty, it seems to me, ought to be by some method that would not require experts. Now, is it possible, and is it likely, and will it ever be possible to have an electrical execution without bringing in electrical experts to prepare the apparatus, before the execution can be performed? Would any one not familiar with electrical apparatus be competent to make the necessary arrangements? Even after the execution had been performed successfully once, twice, or even 10 times, by means of a given apparatus, would you then be willing to allow your sheriff at the next execution to put the apparatus in order, place the electrodes and touch the button? Would you find a sheriff anywhere in the state of New York that would be willing to take that responsibility upon himself? I doubt if after 100 years have passed, electricity will be so understood by non-experts that they would be willing to take the responsibility of performing that act. Now I say that an execution ought to be performed in such a way that the men

whose duty it is to perform it according to law, will be able to perform it without calling in two or three experts.

Mr. Morrison—Our business requires that we should state our objections to the use of electricity for executions. I think that the case in hand ought to be treated from another standpoint, the standpoint of where this idea of executing criminals originated, and what was the motive of those who pressed it upon the government of the state of New York. So far as I have ascertained, it is not a question of dealing kindly with the men you are going to deprive of life. It was not that the criminal might die a painless death. It was not that a benefit should be conferred upon the people of this and of other countries. It was to enable an individual to advance his private interests and gratify his personal malice in pitting one system of electric lighting against another system. Even if that gentleman should be elevated to the high rank of the executioner of Paris, I doubt if it would pay him for the contempt he will earn for himself from the men whose profession he soiled. I do not desire to touch upon the question which has been raised, and settled to their entire satisfaction by the medical and other scientific experts employed in this case. One point, however, seems to me important; that is, the little danger accompanying the use of electricity for any purpose whatever, whether for light, power, or anything else. A set of statistics was furnished recently which read something like this: So many men killed by falling off a scaffolding, and breaking their necks on the pavement; so many men by runaway horses; so many by explosions; so many by other causes, and so many killed by electricity. And among the deaths quoted there is no business that presents relatively so few fatal accidents.

I could enumerate case after case which would show that gas is more dangerous than anything else that you use in daily life. The water which you use, if improperly applied, is a death-dealing agent. Nobody would blame the bricks that the man is carrying up on the hod, if a man walking along three or four stories below happens to receive one upon his head and has his brains knocked out. A buzz-saw does not make a very good seat for a man to sit down upon, but a man of sense will not sit down upon it. Electricity is not a good plaything, if it is used for arc lighting or for power, or for any of these commercial purposes; but if it is used with judgment, with the ordinary safeguards which experience has thrown about it, it is as harmless as that wood upon which I lay my hand. Our friends seem to lay particular stress upon the fact that the men who are advocating this execution business say that the current will kill a man. Of course it will kill a man. So will a hangman's rope kill a man; so will a big knife over in Paris. That knife will kill people; and I think that is about as painless a death as anything I know of. We are dealing with an element which, if not properly controlled, will produce death. So will the ice which you buy in the streets.

This law is upon the statute books of New York. It is with you to-day, and it is incumbent upon the electric light men of New York to get rid of it. It is incumbent upon the members of the National Electric Light Association to do everything in their power to get rid of it. Do everything that you can do to open the eyes of the governor of New York, so that the case may be presented to your next legislature, and enable this disgraceful law to be wiped from the statute book.

Mr. Lynch—I think it would be a great deal more fitting and courteous and bear a great deal more force if the association is to present the petition and resolution as presented by Dr. Moses, that they should be presented by a committee, and I would move that a committee be appointed by the chair for that purpose.

This motion was carried, the committee to be appointed later.

The discussion on the central station papers, of Mr. Law and Messrs. Remington and Henthorn, was then taken up.

DISCUSSION ON THE PAPERS OF MR. LAW AND OF MESSRS. HENTHORN AND REMINGTON.

Mr. C. J. Field—In regard to the steam plants in these two stations, I think there is an opportunity here for us to get some data of comparison in regard to the relative economy of high-speed engines and low-speed engines. We have had one side of it laid before us in two papers, claiming every advantage that could be claimed for the low-speed engine over the high-speed engine with single cylinders or compound, but we have not had an opportunity to hear from the other side, and as I happen to be engaged in trying to put in what I hope will be a good steam plant, I think there is an opportunity to draw out remark or data as to the true economy. What we are trying to get is, what is best for earning dividends; trying to spend as much as will bring us the best returns. We will grant the same boiler plant. Offset the difference in cost with the saving in steam economy, and I think you will find that it will be largely in favor of the high-speed, non-condensing or condensing. I do not think the cost of such a plant as that at Providence (including all the plant with its countershafting, etc.), would be far from \$40 to \$50 per horse-power. You could put in, I know by experience, a compound high-speed plant 300 h. p. engine for a cost of say \$15 a horse-power. Now is that difference in cost to be made up by any saving? As far as I can figure, it is in favor of the high-speed, and as far as general theory goes, I think it is in favor of high-speed. As far as wear and tear are concerned, I think there is not much difference. But the reserve plant to be put in, on the other hand, must be taken into consideration. I would be glad to hear from others.

Mr. Henthorn—We will concede to the gentleman, that a slow-speed engine costs more money at the outset, but there are other matters than the question of first cost. There is the cost of running. Our engine has been guaranteed by the builders to develop a horse-power for 12.6 pounds of water. If you have a station that takes about 1,000 h. p., one pound of water per horse-power represents approximately \$2,000 a year for every pound of water above 12.6; which represents one per cent. dividend on \$2,000 capital. If you increase that up to what a high-speed engine would consume, or in the neighborhood of 17 pounds, possibly above it, there is a difference of about \$10,000 in the running expenses. Of course the steam plant that we put in cost about \$40 a horse-power.

Mr. Field—May I ask if it is claimed that the engines will give that economy under a varying load, which we would have in any electric light station?

Mr. Henthorn—The guarantee covers a variation of 75 h. p.

Mr. Field—A plant being laid out now with high speed and good boiler plant and economizers is expected to get down to 15 or 16 pounds of water. I think if you compare the cost of that plant with the cost of Mr. Henthorn's plant and give it full credit for economy under varying loads, that you will grant that compound high speed will carry the wear and tear under varying loads.

Mr. T. Carpenter Smith—This discussion is taking a very useful shape. We ought to look at the economical side as well as the engineering side. If you are using an engine that can run on 12.6 pounds of water, and a man up the street has an engine using 18 pounds, and if he can keep his lights going day and night without breaking down, he will beat you on your 12-pound engine every time, if you have a break-down once a month. I am an engineer myself, and much in favor of economy, at the steam end of the plant. That is where the money is made or lost. Twelve pounds of water as against 18 is undoubtedly a great factor, and will pay a dividend if you can keep it up; but on that engine there are seven stuffing boxes, and piston rods to look after, and there are in the neighborhood of 50 or 60 steam joints and jackets and pockets and everything of that kind to keep tight, and 12 valves to leak. The engine that I am using and want to keep on using is a compound engine, guaranteed to take 18 pounds of water; it has one valve to do the whole business. It has no stuffing boxes on it except one against the exhaust. It is internally lubricated, so that you use no oil except what is taken up by waste to oil the bearings. This engine can be run night and day, and the repairs are limited to certain parts. Mr. Henthorn has enough to do to look after keeping his lights going without keeping an engine to look after. I think it will be a question whether you can get 12 pounds of water for six months. I think that after the engine has run four or five months, some day the engineer will have the valve out on the floor for a few minutes, when his other piston will break down, and before he can replace that valve and start up again he will damage his business more than he will save in water in 10 years. I do not agree with Mr. Law that the compound condensing engine is the most economical. We want to build an electric light station for simplicity in the machinery and get rid of everything we can.

Mr. F. H. Ball—I want to ask Mr. Henthorn a question. I noticed that he mentioned that his engine is guaranteed to deliver power at 12.6 pounds of water. Are his pumps driven by the engines?

Mr. Henthorn—Yes, Sir.

Mr. Ball—Then, if that is so, a part of the power delivered by this engine is used for driving the pumps, and that much of the power is not available, so that this result that he speaks of running under these conditions, the 12.6 pounds, is deceptive. Part of this power is absorbed in driving your pumps. It is not available for lighting. Another point I would like to ask is, if he knows anything about the friction of this engine with its three cylinders, twelve valves and seven stuffing boxes, etc., and of the line shafting?

Mr. Henthorn—No, Sir.

Mr. Ball—It is evident that there must be considerable friction, and probably the load could not be constantly kept up to the capacity of the engine. It would be very interesting to other managers to know what the consumption of coal would be per arc light per hour.

Mr. W. C. Kerr, of New York—An important question with Mr. Henthorn's station is its extension. We always leave a lot of work in our business for posterity, but posterity never did anything for us, and when you begin to work for posterity you begin to work on a very indefinite basis. We should work with an eye to an elastic station which can be extended. The station which Mr. Henthorn has shown is an inelastic station, because it

costs so much money that you cannot afford to change it. We know what changes have been made in electric light stations in the last few years. A good many things have to be refurnished, and in some stations it costs a great deal of money; in others, very little money. Now the station which is the most elastic to begin with, can make these changes for putting in new electrical apparatus at a very low cost. Yet I do not believe the time has yet come, nor that it will come within the next ten years, when we can build electric light stations as they do water works. The art is not far enough advanced. While I do not doubt that this is an excellent station which Mr. Henthorn has shown us, I would only criticise the general plan at all in that it is too expensive for the present state of the art. Electrical discoveries may be made very shortly which will seriously impair the utility of that station, and it would cost too much money to change.

As to the question of striving for the lowest possible amount of steam economy, I have great doubt as to its utility. Steam engineering is not an exact science; so it is a very difficult thing for us to reason exactly what the ratio is between this economy of steam and some other factors. We, however, do know that, strange to say, the electric light plants that have made the most money are not those that have the most economical plants. It is a fact that the most economical plants have not produced the most money. I know of cases where 6,000 lights have been out in a single night in one city, where the results were extremely bad, where the loss could hardly be measured. I also know of a certain station, composed of about twelve engines, two of which were very fine 500 h. p. engines, high speed, simple type. The large engines in one year caused twelve stoppages of the plant, and the ten engines never had a stoppage against them. The construction of an electric light station must be considered from the standpoint of a good many things besides fine engineering.

STANDARDIZING POTENTIAL FOR ELECTRIC RAILWAYS.

Mr. E. T. Lynch, Jr.—I have been surprised to learn that, notwithstanding the number of persons engaged in electric street railway business, none of the companies seem to be receiving current from the local electric light companies. Reasons have occurred to me why it might be arranged that lighting companies could supply current to railways. There seems to be a community of interest. There is danger in the future of street railway companies having stations in the centre of cities establishing a system of motor business, which would interfere very seriously with electric light business. The trouble is that there has been no standard of electromotive force used by the railways. One company uses 400 volts, another 415, another 450, and another 500. The electric light people have not wanted to supply these companies because they would have to buy different apparatus for every railway. If we could have a standard of electromotive force and four or five sets of large machines, we could supply a dozen railways from a station. This power is required during the daytime when the electric light station is to a certain extent idle. I have drawn up the following resolution :—

WHEREAS, It is the belief of the members of this association that the electric motor service upon street railways will require a service of electric current for the motor that will be reliable and constant, and that the various electric light stations are capable of generating and distributing such current,

Resolved, That a committee of three be appointed by the President, who shall endeavor to make such arrangements with the manufacturing companies, that they should adopt some standard potential to be used upon the various railways. The committee also to collect such data regarding the supply of current to railways as may be deemed of interest to the association.

Mr. T. C. Smith—I have had occasion, Mr. President, to inquire with regard to the supply of current to street railways from electric light stations, and I found in nearly every case it has been purely a question of cost. The railroad people say electric light men want too much, and the electric light company says :—"We do not propose to invest a lot of money in apparatus and tear our stations to pieces unless we get a good price." I think that Mr. Lynch has made one very good point.

The President—The progress made in this direction would be slow, and encounter a good many obstacles. I still think the tendency of the time is toward standardizing. We can remember when railways were built with all sorts of gauges. We now have them of standard gauge, and all of us who are in the business know what a multiplicity of differences we have, how difficult it is for a man who has had his service from one system to get service from another system. He has to go to the expense of changing a good many things. There has been some talk abroad on this same topic, and I think some good will come in the way suggested by Mr. Lynch. I know we will have the interests of the manufacturing companies to contend with, as each one is striving to give somebody something that he will have to renew only through him; their interests are all in that direction, but it is only a question of time, gentlemen, before these things must disappear. They must come to a certain standard, which will be the result of the experience of all, and will be dictated by economy.

Mr. Lynch's resolution was adopted. The chair appointed Mr. Lynch as chairman of the committee, and as the other members, Mr. T. C. Smith and Mr. M. J. Perry.

Mr. Morrison moved that a committee of five be appointed to present nominations to the convention for members of the executive committee, and to suggest a place of meeting for the next convention. Carried.

Mr. S. M. Young then read a paper by Mr. Wm. Bracken on

ELECTRIC TRACTION BY STORAGE BATTERIES.

I have been invited to address you on the subject of electric traction by storage batteries.

I once heard a judge tell a loquacious lawyer that he must assume the court knew *some* law. I will assume that you all possess a sufficient general acquaintance with the storage battery in lighting and in traction; but there may be some features, chiefly commercial, that have not come under your observation. My observations cover a period of over three years, during which time the company with which I am associated has directed its talents and energy to the development of storage battery traction. You all appreciate the difficulty of the task—not alone difficulties inherent in the system itself, but difficulties arising from the skepticism and lack of sympathy, I regret to say, of a very large majority of the electric community. We all know how much skepticism on the part of street railway men has had to be overcome in electric traction of any kind. But this is not to be wondered at, for there is nothing harder to accomplish than to supersede an old and well-established system

The first experiments made with electric cars were calculated to increase this distrust and to throw disfavor on electric traction ; for it is a characteristic of inventors to be so far carried away by their enthusiasm as to commit great indiscretions in carrying on experiments in public. It was on this account that the early experiments of Daft, in 1883, and of other well-known electrical engineers in succeeding years, while they created wonder, did not beget confidence. I may say without any invidiousness that, two years ago, there was not a single electric car run in this country that proved anything more than possibilities.

There were probably two dozen cars run at that time by the overhead wire system, but so unsatisfactorily that people who went to see them came away shaking their heads. Now distrust has disappeared, and electric traction has grown so rapidly that to-day there are no less than one hundred street car lines in this country that are either running their cars by electricity or are in course of introducing the system. Electric traction has, beyond all doubt, come to stay. But the large cities are threatened with cable traction. The storage battery proposes to challenge its supremacy.

When the storage battery first became known in a practical and commercial form by the experiments of Planté, in 1859, scientists foresaw its great future ; and when corporations were formed to exploit the storage battery, the people of Europe, influenced perhaps by the extravagant praises of Sir William Thomson and others, put an enormous amount of capital into such enterprises. Almost all of them proved commercial failures; first, because they were ahead of the time; and second, because the public were led to expect more than the storage battery, in its then crude form, could accomplish.

Although much has been written about its nature and characteristics, the treatment of the storage battery, both in manufacture and use, has, until recently, been purely empirical. That stage, fortunately, has been passed ; and now, with intelligent care, the storage battery is not only a valuable adjunct in lighting, but is becoming a very prominent factor in traction.

The advantages of storage battery traction, assuming that it is practical and economical, are too obvious for me to occupy your time in recounting. The chief practical obstacle was the handling of the batteries. That was the most difficult and the last obstacle to be overcome by us. Two improvements removed these difficulties. First, the flexible connector, which enables us to couple up or remove cells with great rapidity ; and secondly, the battery rack, occupying a floor space of 24 x 7 feet on each side of the track, wherein we can store a sufficient number of batteries to run from 10 to 20 cars. This rack represents stall room for 150 horses, or say 6,000 square feet. I regard this rack as the greatest improvement hitherto made in storage battery traction. By its aid we remove the batteries from a car and replace them by another set in from two to three minutes. Indeed, our cars on Madison avenue—and I may say here that we begin to-day to run ten cars in daily service—have to leave the station on six minutes headway. In the afternoon trips there is but six minutes interval between their arrival and departure, and they all receive their batteries from the same rack. When the car enters this rack its panels are dropped down on either side, and thus form bridges over which the batteries are withdrawn from and replaced in the car. While this change is being made, a competent person inspects the regulators of the car. The motors, gearing and connections are only inspected once a day, and that at the end of the day's work. The great bugbear of how to store the batteries is no longer an element in storage battery traction.

From my observation of our recent work on Fourth and Madison avenues, now that we are running a number of cars—under very unfavorable conditions as to station room and the like—I am led to believe that the storage battery car is as free, if not freer, from accident as cars that are run by the overhead system. The motors are, I think, subjected to less trying conditions, owing to

the fact that the E. M. F. is always uniform. The batteries never give out on the trip. It is impossible for them to do so, as they leave the station with 35 electrical h. p. hours stored in them, and do not consume quite 12 in the round trip of 12 miles. We have never short circuited the battery in service. When the current required exceeds 150 amperes, the battery is automatically cut-out. When we used rigid connectors, we frequently had difficulty with their breaking, and the flexible connector has, until recently, given us some trouble from time to time by jumping out of position while the car is in service; but with recent improvements, disconnection of the batteries, while the car is in service, is now rendered almost impossible. For several months past we have had absolutely no trouble from our regulators. In any event there are two on the car, so that if one should fail the car may be operated from the other end. Our first standard car has run in three months over 6,000 miles, and carried over 80,000 passengers, never having missed but one-half a trip in that time, and that arose from a bent axle. It has never had an accident or stoppage of any kind while in service. Do not be skeptical at the assertion when I tell you that we have never spent a dollar on that car in the way of repairs or alterations.

You will naturally ask, how about the life of the battery? I answer that from our observation we have nothing to fear on that score. We only ask a life of six months from the positive plates; we know that they will last much longer than that. The chief reasons why the short life of a storage battery has been so much talked about is that it has, until recently, cost so much to manufacture the battery. Now, the material for your battery you have to buy, as to a great part of it, but once, because the discarded battery can be made over new. The raw material in two sets of batteries capable of running a car 120 miles a day, costs, exclusive of the containing jars, about $300. Have you machinery and devices requisite for manufacturing this raw material cheaply into a battery? If you have, you need have nothing to fear on the score of economy. It will cost $4,000 to purchase enough horses to run a 16-foot car 120 miles a day; it will cost about $1,500 to purchase enough battery to do that work. The batteries can be maintained for about one-half what it costs to maintain the horses; and by maintaining I mean replacements as well as feed. Can we then have any further doubt as to the relative economy of storage battery traction?

The cars on the Madison and Fourth avenue line take one electrical h. p. hour per mile. The road has some long gradients. The grade at Centre street is over 4½ per cent., and 600 feet in length.

The cost of motive power for a car-day of 75 miles we estimate at $3.40, as against $7.50 for horses. Five dollars for 75 miles ought to cover the cost in winter. By motive power we mean the cost of energy at two cents per h. p. hour, and $700 per annum for maintenance of batteries and motors. To those who may think that two cents per h. p. hour is a low estimate, we would say that power has been offered to us in New York, to be delivered to us at our station, at the price above named. In towns outside of New York offers have been made to supply current at lower figures. The more level the road the cheaper, obviously, will be the cost of motive power. This is more particularly true of the storage battery, which in excessively steep and long grades becomes heated. The chemical energy, instead of exhibiting itself in the form of electrical energy, exhibits itself in the form of heat, with consequent injury to the battery. Our cars will ascend very steep grades; but do not deem it economical to attempt grades of more than 6 per cent., and they must be short at that rate. But there are few roads offering more and steeper grades than the road we are now operating on in New York. Each car has two sets of battery. A set is easily charged in about two-thirds of the time the other is in service. No time is lost in charging, as the battery is automatically put in circuit with the dynamo as soon as it is withdrawn from the car. Now that we have a complete group of cars in service in New York, and hope to follow those by another group of ten, we will all know more about storage battery traction at our next annual meeting.

The President then announced the following committee to nominate the executive committee and to choose a place for the next convention:—Chairman, J. F. Morrison; E. T. Lynch, Jr., C. C. Martin, E. F. Peck and A. J. De Camp.

THURSDAY MORNING SESSION.

Mr. A. R. Foote—(Presenting the report of the committee on legislation.) The committee held a meeting yesterday morning, and as a result submit the following as a plan of work. (See ELECTRICAL ENGINEER for June, 1889, p. 284.) Mr. Foote in conclusion, said:—That plan of work is submitted to the convention for its action. In addition, the committee adopted the resolutions read by Dr. Moses yesterday on the subject of electrical executions.

The report was received and filed.

The President—We will hear from the secretary a communication from Mr. Steuart, chairman of the committee on patent legislation.

The secretary read the following letter:—

BALTIMORE, Aug. 5, 1889.

Allan V. Garratt, Esq., Niagara Falls, N. Y.

DEAR SIR—I have your favor of some days since, and am sorry to say I will be unable to be with you at the convention at Niagara. My partner is away, and I am so busy that I will be unable to leave.

Please say to the convention for me that the plans of the legal committee are all in shape, to begin operations upon the Fifty-first Congress as soon as it convenes. Judge Culberson, who was chairman of the Judiciary Committee of the last session, I am told, will be upon the same committee during the coming winter, and out of courtesy to him our bill will be taken up among the very first acted upon and his previous report adopted. I hope we may be able to induce him and the other members of the committee to recommend the passage of the bill as it was originally filed, providing for five judges instead of three, as recommended by the committee report of last year. There is every reason to suppose that we will have little trouble in passing the bill in the Fifty-first Congress, and if we succeed, the National Electric Light Association may congratulate itself upon having achieved a very great reform in the patent system of the United States. The work of this committee during the next six months will have my best efforts, and I feel very sanguine of success.

Very truly yours, ARTHUR STEUART.

This communication was received, and ordered to be spread upon the minutes.

Mr. C. C. Haskins, of Chicago, then read a paper on "Dynamo Room Accessories for Intensity Potential and Resistance Measurements."

Mr. Haskins's paper consisted of a carefully prepared historical sketch of current and potential measuring apparatus, illustrated by drawings, and enlivened by the characteristic humor of the author.

Concluding, Mr. Haskins said:—"Every now and then the suggestion is made to place a permanent ground on an arc line, in order to know when a second ground occurs. The use of a safety fuse comes in at once as a natural sequence. The suggestion is fraught with great danger to both life and property, and takes no heed of the time it requires a good healthy current to 'get there.' While it is true that the first ground does no harm, *per se*, it must be remembered that without a first ground a second ground is an impossibility, and the second ground is the troublesome one. There is a fascination about rigging up some sort of an arrangement for telling when there is trouble, rather than to keep the trouble at bay on general principles. An acquaintance brought to me one day, with his face all aglow, a sketch of a piece of clockwork, ingeniously arranged to make an instantaneous contact to ground once an hour while the plant was running. This ground contact had, between the line and ground, a safety device which held up a key to a second circuit, that could only close when the fuse melted. On this second circuit he had a battery and a bell located so that every one in the room must hear it, and continue to hear it until it was switched out or the battery ran down. It never worked, for I convinced him of its impracticability by asking him to form the second ground through his body as an experimental test.

Testing sets are made by various firms, which do excellently well, for the species of measuring which may be necessary about the station or on the line. The combination includes a Wheatstone bridge with a normal capacity up to over a megohm, and down to fractions of an ohm. With an additional box containing extra coils, and a split plug and cord attachment, this capacity may be carried to twice or three times its ordinary capacity. A battery and galvanometer finishes the set, which is made up in two portable cases. No electric light station or plant of any consequence should be without some such means of electrical measurement, and no dynamo should be run without a daily test of insulation and a test of copper resistance. A bad joint may cost many pounds of coal, but a ground leak may be far more expensive in many ways, while both may be prevented by the proper constant use of a set of testing instruments. A daily record should be kept of these tests, together with the condition of the weather, etc. I have read somewhere of a ladder which was seen in a dream, the three principal rounds of which are faith, hope and charity, the greatest of these being charity. We have in the electrical ladder three principal rounds also. They are current, potential and insulation."

Mr. Benjamin Rhodes then read the following paper on

ECONOMICAL SIZE OF LINE WIRE FOR CONSTANT CURRENT CIRCUITS.

The writer has for some time been accustomed to use a formula for finding the economical size of line wire for constant current circuits, and has been requested to present it at this time. With the knowledge that it is not new, and yet that it is needed by many practical electricians, the following is submitted:—

Let X = diameter of line wire in mils.
Let A = length of circuit in miles.
Let B = price of copper per pound.
Let C = cost of power per year per horse-power.
Let E = amperes of current.

When any plant is about to be established, B and E are known. C can be determined near enough for our purpose, and A will be found to be immaterial.

$.016\ X^2 =$ pounds of wire per mile.
$.016\ B\ X^2 =$ cost per mile of wire.
$.0016\ B\ X^2 =$ interest and depreciation at 10 per cent.
$.0016\ A\ B\ X^2 =$ annual cost of wire. (1)

$\frac{54{,}577}{X} =$ ohms per mile.

$\frac{54{,}577\ E^2}{X^2} =$ watts per mile.

$\frac{54{,}577\ B^2}{746\ X^2} =$ horse-power lost in transmission per mile.

$\frac{54{,}577\ C\ E^2}{746\ X^2} =$ cost of same.

$\frac{54{,}577\ A\ C\ E^2}{746\ X^2} =$ annual cost of power lost in entire circuit. (2)

It is plain that with any increase in the size of wire the value of (1) will increase, while (2) will diminish, and the economical value of X will be such that the sum of (1) and (2) will be a minimum.

Let $u =$ this sum :—

$$u = .0016\ A\ B\ X^2 + \frac{54{,}577\ A\ C\ E^2}{746\ X^2}$$

Differentiating, $\frac{d\,u}{d\,x} = .0032\ B\ X - \frac{109{,}154\ E^2\ C}{746\ X^3}$.

Placing this equal to zero, and reducing, we have :—

$$X^4 = \frac{45{,}700\ E^2\ C}{B}$$

This formula shows that the diameter of wire depends on the price of copper, cost of power and quantity of current, and is entirely independent of the length of the circuit and the voltage.

The differential co-efficient shows that the formula is in harmony with Sir William Thomson's rule that "the additional running expense due to the resistance of the conductor shall equal the interest on its first cost."

Price of copper refers to the bare wire without any covering or insulation whatever. The insulating cover is a mere matter of choice, like a brick, stone or frame station.

A few examples are added for illustration, the price of copper assumed at twenty cents per pound for facility of calculation.

What size wire should be used in the transmission of power plant using a 40-ampere current, power costing $100 per year per horse-power?

Here $E = 40$, $C = 100$, $B = 20$. Substituting, $X = 427$ mils, or nearly No. 0000 wire B. and S. gauge.

If the power cost $50 per year then $C = 50$ and $X = 359$, or 00 B. and S. With water power at $10 per year, $X = 240$, or between Nos. 2 and 3 B. and S.

Should a 20-ampere current be used in the three cases above, the results would be respectively:—

$X = 302$, larger than No. 1 B. and S.
$X = 250$ larger than No. 2 B. and S.
$X = 170$, between Nos. 5 and 6 B. and S.

What size wire is economical in an ordinary city arc light 10-ampere circuit, steam power costing $50 per year.

$E = 10$, $C = 50$, $B = 20$;
giving $X = 180$ mils, or No. 5 B. and S.

Suppose water power can be furnished at Niagara Falls for $10 per horse-power per year and a 10-ampere current generated by this power be used for street lighting in Buffalo, the entire length of circuit being 50 miles, what is the economical size of line wire?

A substitution in our formula gives $X = 120$ mils, equal to No. 8 B. and S., or exactly No. 11 Birmingham wire gauge.

The President—Gentlemen, we have for the special order of business at 11 o'clock, which has very nearly arrived, the report of the committee on the revision of the constitution and by-laws, through its chairman, Dr. Moses.

[Printed copies of the constitution had been distributed to the members of the association.]

Dr. Moses—The opinions of all the members of the association were sought with regard to certain changes thought advisable then, and we have a mass of material amounting to some 125 letters, some of them quite carefully written, and giving great encouragement to the committee to proceed in these amendments, which are on file with the secretary. The amendments are not many, but comprise a change of some importance in the form of the constitution; and I will call your attention to a few of these points after I have read the proposed constitution.

Dr. Moses then read the proposed constitution (see p. 399), and said :—In this proposed constitution, gentlemen, you will notice that there are certain changes, some of which affect myself and others of my committee materially; but it was thought by me and my coadjutors in this matter that it was important that these changes should be brought about in order to give more homogeneity to the association, and to give it its true position as a body. I hope that the mature deliberation that has been given to this, the labor that has been expended upon it, and the disinterested feeling that has prevailed in forming it, will be acceptable to you.

Mr. Brown—Mr. President, I move that the report of the committee on the revision of the constitution be accepted.

The motion was seconded by Mr. De Camp.

Mr. Lynch—Mr. Chairman, I would suggest that as this proposed constitution is very important, we take it up *seriatim*, and discuss it, article by article, and pass upon it so. One or two little changes I would like to suggest, and I think that would be the most satisfactory to all.

Mr. Morrison—The suggestion is not in order. You accept the report, and then discuss its provisions.

In stating the motion of Mr. Brown, the president used the word "received," instead of "accepted." Mr. Brown drew attention to the difference in the terms, and the president restated the motion correctly. The motion was then put to vote, and the report was accepted.

Mr. Brown—Mr. Chairman, the report of the committee on the revision of the constitution having been accepted, I would now move you that a committee of five be appointed by the president for the formulation of by-laws or rules of order for the association.

Seconded by Mr. Phelps.

Mr. F. H. Whipple—Do I understand that this constitution has been adopted?

The President—Accepted.

Mr. Whipple—What do you mean by "accepted"?

The President—That it is now the constitution of the association.

Mr. Whipple—There is a difference of opinion here as to whether this matter is before the convention, or whether it has been adopted.

The President—The ruling of the Chair is that it is now the constitution of the association. The word used by Mr. Brown was "accepted."

Mr. Lynch—My suggestion was made with the understanding that the report was to be received. I do not think we should quibble as to whether it is adopted or received. Some of the members want to talk on the changes meditated in the constitution.

The President—The discussion is out of order. All discussion to this point must be on Mr. Brown's motion for the appointment of a committee of five on by-laws.

Mr. Morrison moved as a substitute that the executive committee be instructed to prepare by-laws, and Mr. Brown accepted the substitute, which was then adopted by vote.

A paper was then read by Mr. G. W. Mansfield on

ELECTRIC RAILWAYS.

(Abstract.)

For the transportation of people in the streets of towns and cities the success of electricity has been demonstrated, the application made, and a luxuriant growth started.

In 1828 the now great Baltimore and Ohio Railroad started, and horses were used to draw the cars. This might be called the first horse car line in the United States. In 1830 there were 12,866,020 persons in the United States, and not a mile of street railroad. The New York & Harlem Railroad, incorporated in 1831, is usually spoken of as the first street railroad in the country. The first car was run in November, 1832, from Prince street to Harlem bridge.

The census of 1850 gives a population of 23,191,876, and published history but one street railroad. But in ten years the street railroad was in almost every city of any magnitude in the country. In 1880 our population was 50,155,783. Estimating an increase of 33⅓ per cent., in 1890 it will be 66,874,354. For the transportation of this number of people in the streets of our cities and towns the most accurate figures it is possible to obtain show about 425 companies, employing 28,000 cars, 125,000 horses, and operating some 3,500 miles of track. The capital invested is variously estimated from $175,000,000 to $200,000,000. The number of passengers carried is so enormous that it is impossible to obtain figures of any great degree of accuracy. From careful compilations and estimates it is reasonably sure that at least 1,500,000 passengers are transported daily.

Still more striking is the importance of the street railroad business when compared with the magnitude and extent of the steam railroads of the United States. The figures of 1887 show a tabulation of 147,998.60 miles of railroad, and 20,582 passenger cars, and passengers carried but 428,225,513. With nearly an equal number of cars, and 42 times more road, only one-quarter as many passengers were carried. Behold the yet more amazing figures: The horse cars of the City of New York carry 199,491,735 passengers, almost half as many as are carried by all the steam roads in the United States. If to this number are added those carried by the elevated roads, we have the total of 371,021,524, or almost as many passengers are carried in New York city alone as are annually carried by all the steam roads in the whole United States. The street railroads of the state of Massachusetts carry over 44,000,000 more people than all the steam roads in that state. One road alone, the West End of Boston, carries nearly 10,000,000 more than all the steam roads combined.

To show where this tremendous traffic is, I have prepared table i. Most of the figures showing passengers carried were

obtained from reliable sources, and the remainder were estimated from an average obtained from those I was sure of. If you figure for each car six h. p. of electric energy, it will give you a rough idea of the size of an electric central station needed to operate all

TABLE I.—CITIES OF 100,000 POPULATION AND OVER.

Name.	Companies. Elevated.	Companies. Horse.	Miles single track.	Total track-age.	No. of cars.	No. of Horses.	Locomotives.	Total passengers carried.
New York	2	......	60	89	949	......	291	171,529,789
	......	19	143	268	2,300	14,441	......	199,491,735
Brooklyn	3 miles cable included.	14	185	207	2,355	8,410	......	105,975,249
	3	......	24	35	247	......	91	18,632,082
Boston	......	1	211	231	1,584	7,684	......	97,039,919
Providence	......	1	54	54	289	1,414	......	15,582,732
Chicago	44 lines in one system.	7	325	325	2,400	8,279	......	99,348,000
Philadelphia	......	12	302	326	1,512	822	8 dummies.	143,433,959
St. Louis	3 cable.	14	169	169	1,058	4,231	......	50,772,000
Baltimore	......	12	158	158	460	3,167	......	34,837,000
Cincinnati	2 cable.	30 lines. 7	164	164	580	2,644	4 dummies.	31,728,000
New Orleans	......	7	140	140	499	2,019	18 dum's. 7 loco.	24,228,000
San Francisco	2 steam. 8 cable.	10	163	164	707	1,724	3 loco. 39 dum's.	130,860,000
Buffalo	......	2	39	56	198	1,276	......	18,108,203
Washington	......	5	63	63	336	1,684	......	21,892,000
Newark	......	3	53	52	219	1,264	......	15,168,000
Louisville	......	2	112	112	378	Mules. 2,270	......	24,970,000
Cleveland	......	7	123	123	523	Horses. 2,521	......	30,252,000
Pittsburgh	6 cable, 1 electric,	13	113	113	347	1,924	3 dummies.	39,068,000
Jersey City	......	2	35	35	132	825	......	10,725,000
Detroit	3 electric.	4	65	65	263	1,682	......	32,184,000
Milwaukee	......	3	68	68	208	1,:88	2 loco.	16,744,000
Albany	......	3	19	30	103	424	......	4,278,927
Indianapolis	Consolidated.	1	40	40	99	648	......	9,720,000
Kansas City	6 cable.	7	124	124	469	613	38 dum's & mot'rs.	33,969,000
St. Paul	1 cable.	1	74	74	154	816	......	28,608,000
Omaha	2 cable, 3 electric.	1	61	61	167	580	24 motors.	20,540,000
Minneapolis	Consolidated.	1	66	66	160	1,104	......	14,352,000
Totals.	......	189	3,103	3,414	18,645	77,884	......	1,434,057,595

Five elevated roads, 27 cable, 147 horse, 7 electric, 3 steam and horse combined—189, total; 18,645 cars, 394 locomotives, 184 dummies and motors; 77,884 horses, 2,270 mules—80,154. About 24,000 horses are annually disabled.

the cars. In New York city dynamo capacity of 13,800 h. p. would be demanded, in Boston 9,504 h. p. This is destined to come as surely as the days succeed each other. In Boston it has come, and a station of approximately 8,000 h. p. is already in the hands of the engineers. Every large city of the land demands and seeks cleaner, surer, and more rapid transit.

The Baldwin Locomotive Works have for years been engaged in the manufacture of steam dummies for street railways, expending the highest order of talent and skill upon the vexed problem as to how to use steam for the haulage of street cars. Motors weighing from 13,000 to 27,000 pounds have been built. The power of these engines can be judged from their pulling capacity, which varies from 320 to 634 tons on a level, and from 16 to 43 tons on a 4 per cent. grade. They were built to run at speeds from 10 to 15 miles per hour, and provided with all possible safeguards and conveniences. Powerful brakes were used, coke was burned to avoid smoke, and mufflers provided for the exhaust and safety valves. Their economy in working has not been very freely published. From reliable and authentic sources we learn that the lowest fuel consumption is 6½ pounds of coke per mile run. The

TABLE II.—ELECTRIC STREET RAILROADS.

	1885.	1886.	1887.	1888.	Jan 1-July 1, 1889. Oper-ating.	Build-ing.	Total	Total.
Number of electric railways	3	5	7	33	19	42	61	109
Number of miles of road	7.5	28	29	130.5	113	267	380	575
Number of cars	13	39	81	265	174	364	538	936

average is from 15 to 12 pounds when ordinary grades are ascended. The total cost of operating per mile has been in some instances reported to be but 3½ cents, but in other cases it was found to be over 20 cents per car mile. It is needless to say that in spite of all the skill, time and money spent upon them, they have not proven, except in a few isolated cases, either satisfactory or economical.

The figures of table ii. certainly show that the growth of electric traction has in four years exceeded the most sanguine prediction. The remarkable contract which the West End Street Railway Co. of Boston, the largest street railway company in the world, signed recently with the Thomson-Houston Electric Co., is not included under the heading, "roads building in 1889."

The West End company, of Boston, owns 217 miles of track, and 1,584 cars, all of which are to be equipped so as to be operated with electricity. Add these to the list, and how will it stand. If it be within the bounds of the supply men, at least 75 miles will be built this summer, and 100 or more cars equipped. As an interesting comparison regarding the new industry, note the following figures:—

TABLE III.—STEAM AND WATER POWER EMPLOYED IN ELECTRICAL INDUSTRY.

	1870.	1880.	1890.
Total h. p., both water and steam, engaged in the whole manufacturing industry of the United States	2,346,142	5,410,837	Estimated, 5,255,582
Total h. p. engaged in the electric lighting and power industry	0	1,000	500,000
Total h. p. engaged in electric railway industry	0	0	30,000

In meeting the demand for better city transit there are many considerations that claim our most careful attention. The conditions to be met are widely different from all other electrical applications. Essentially we have, first, a steam engine; second, a dynamo; third, a conductor; and fourth, a motor mounted upon a vehicle and subjected to mechanical and physical conditions more extreme and severe than have heretofore been imposed upon any electrical machinery. The engine has to stand the bulk of the fighting.

The extreme liability of short circuits on the road from falling wires, careless drivers turning the current on too suddenly when starting, and a variety of accidents that may happen on the very best roads, render it important that the engine have its main moving parts at least 20 per cent. heavier than ordinarily. Under the extreme fluctuations of load, keys, nuts and bolts will work loose. An engineer in a large station recently told me that he practically took to pieces and put together nearly every month a 100 h. p. engine running an 80 h. p. dynamo, whereas prior to the time that it had been connected to a railway dynamo it had given practically no trouble, although worked well up to its capacity.

Hanscom, of cable railroading fame, writes:—"We do not consider it good engineering to design an engine to suit the general average of all lines in the country." He argues special engines for every road. Mr. C. B. Holmes, president of the Chicago Cable Co., writes:—"I would recommend that the strength of parts and weight of fly-wheel be at least one-third greater than the usual run of engine power." Our business is analogous, and I think we should heed their counsel.

A compound engine rated at 109 h. p., running an 80 h. p. dynamo, under test recently, gave the following:—

Friction card with dynamo but no current, 11.65 h. p.
Aggregate horse-power of cards, 1,24:.74 h. p.
Average horse-power of cards, 56.67 h. p.
Maximum card, 120.79 h. p.
Minimum card, 15.56 h. p.

The cards were taken at 10 minute intervals for four hours. There were at the time three electric cars on the line, each towing another. As the day was a pleasant Sunday, every car was crowded. During the same time current and potential readings were taken on the line at the station. The average gave 30 h. p., or an average efficiency of 54.6 per cent. for the total time. Every moment deducted that no current was flowing would raise this efficiency. At times the efficiency was far higher than this. The road conditions were severe, the grades ran as high as 10 per cent., and there were numerous others of five and seven per cent. The extreme current fluctuations were noted in one minute's variation from 45 amperes to 140. The potential was very constant. On another small road the extremes varied from the friction load to nearly 85 h. p. on a 100 h. p. engine. These extremes would happen even during the time a three-impression card was being taken. Under such conditions the question of coal economy is a troublesome one. On large roads, unquestionably a far better showing would be possible.

Laying aside the question of coal economy, which is cheap in comparison to food for horses, the best engine is the one that handles the average work with the least repairs. On some small roads the ratio of engine friction to average daily load may be large. The great majority of roads, however, will have a sufficient number of cars to so reduce the ratio of extremes to the average load that the engine can work at its most economical point of cut-off the major part of the time, and raise the average load to such a point above the friction load that the per cent. lost will be comparatively small.

Almost the first question asked by the manager of an electric light company when an application has been made to him for power, is: "How much electric power must I allow per car?" No man can give a definite answer to this question that will meet all conditions.

If the following facts are known, a fair judgment can be made:—1. Number of cars simultaneously operated; 2. Speed and nature of service; 3. Maximum grade, and number of grades; 4. Scheduled location of cars in reference to grades; 5. Motor cars to be used to tow other cars or not; 6. Any peculiarities in regard to the distribution of cars; 7. Condition of track; 8. Location of track in reference to power house.

On a portion of the Cambridge division of the West End Street Railway Co.'s road, of Boston, the Thomson-Houston company's motors commenced running Feb. 16, 1889. Up to July 1, 165,781 miles and 25,505 round trips had been made with a loss of but 325 miles, or .19 of one per cent. (49 round trips). During this time nearly 1,500,000 passengers were carried. This, in view of the fact that during the entire time one, and part of the time two, tow cars were drawn, is remarkable.

On a portion of the route there is an open bridge about 1,800 feet long, on which is located one draw, which is opened from 20 to 30 times a day. Over this bridge 1,810 cars per day pass, or on the average of one every three-quarters of a minute, and at some portions of the day they run at half-minute intervals. The teaming on this street is also very heavy, necessitating constant stopping. You will see from these figures what the loss of current or a motor burn-out causing delay would mean. The record, however, has been magnificent. As the dynamos are run by the Cambridge Electric Light Co., and are so arranged that the same engines furnish power and lights for their own purposes, as yet only approximate data as to the fuel consumption, etc., has been possible. A few electrical tests have been made. Ammeter and voltmeter readings were taken at the station every 15 minutes, four readings per minute, or at 15 second intervals. This was kept up from 6.30 A. M. to 12.30 A. M. next morning for five days. In all, 1,480 readings were taken. The average of these readings gave for 12.6 cars in continuous service, 111.6 amperes, 500 volts, or 74.8 h. p. Per car this is 8.8 amperes and 5.9 electrical h. p. The average number of passengers carried was about 58 per round trip. We now have 32 cars in operation, and observations, in so far as they have been taken, show a marked decrease in h. p. per car. At Richmond, Va., some rough tests gave the electrical h. p. required per car at the station as from 4 to 5. On the road at Lafayette, Ills., the figures of Dr. Bell show the remarkable low figure of 2.5 electrical h. p. There are a number of circumstances on this road that would tend to make this figure so low. The cars are smaller than those ordinarily used, and I should judge that there were other circumstances entering into the calculation that would tend to reduce it. However, it well shows, possibly, one extreme in railroading

The other extreme might be cited in the case of the Lynn road, Highland division. Here only one car is in operation. In the course of its route it ascends a hill graded at the rate of 8.7 per cent. for 300 feet, and immediately passes down on the other side. In this case the engine was indicated. Five cards were taken when the car was ascending the grade, the average of which was 52.2 h. p. If we allowed a dynamo efficiency of 90 per cent., this would indicate an electrical horse-power of 47 h. p. This is unquestionably a very extreme and exceptional case. I might add, incidentally, that the car pays handsomely.

At Plymouth, Mass., a road having many heavy grades, the maximum being over 10 per cent., and operating but three electric cars, each with tow cars, the electrical horse-power at the station per car was approximately 7.72 h. p. On the cars the extremes vary obviously, according to speed, grades, load, etc. It frequently reaches from four to five times the average value during the total time. In Lynn the variation is enormous. In Cambridge the current frequently rises to from 65 to 70 amperes, or about 42 h. p. Especially is this the case on starting. You can see from these figures the impossibility of giving only the most approximate figures in this direction unless every detail as to operation and conditions are known. I feel, however, that on roads having no grades over 5 per cent., and operating under 10 motor cars with tow cars, 15 h. p. per car would be a safe figure for dynamo capacity. On large roads this figure could be reduced to 12, and possibly 10, h. p. per car, while on small three or five car roads with heavy grades 18 or 20 h. p. might not be any too much.

From estimations based upon many figures, I feel certain that a total electrical efficiency of at least 70 per cent. can be obtained, and a total commercial efficiency measured from the indicated horse-power of the engine to the car wheel horse-power (W. H. P.) of from 45 to 50 per cent. If the road-bed, rolling-stock, and all the electrical apparatus is maintained as it should be, I see no reason why this figure cannot be exceeded.

There is one point which is of vital interest to the managers of electric light companies, and this is how they shall charge the railway companies for power. I have already shown you that it is an exceedingly difficult thing to estimate upon the requisite power, as the conditions are so fluctuating and so variable. After, however, the question of the amount of power has been settled, the next point to determine is whether they shall charge the railway company by the hour, by the day, or by the car mile. We have a large number of roads already hiring power of local companies; all of the methods just mentioned are in use. Upon small roads where the schedule of the railway company is such that they have only a few cars running continuously, meeting emergencies by extras, and where the grades are heavy, a satisfactory basis has been to charge so much per day per car, the price ranging all the way from $3 to $5, $6, and even $7. When the roads are of moderate size, or are subject to many variations and sudden demands on the part of the public for better facilities, or when the line runs to some resort and the main bulk of business lay in picnics, etc., charges on the hour basis is sometimes preferred. This price varies from 15 to 30 cents per hour. On larger systems, where the schedule is definite and fixed, the mileage basis is the preferable by far. The prices on this basis range from two to six cents.

In the East, where coal ranges from $4 to $5 per ton, naturally the prices could not compete with the railroads of the natural gas and coal regions, where fuel can be obtained for almost nothing, as in some cases for 10 cents per ton.

I would like now to enter a wedge here in favor of the very best of construction. Your own experience has probably dictated that there is no economy if the original construction be put in with either inferior or faulty material or apparatus. It is most important that the overhead construction, the track circuit, the wiring of the cars, and all other details be as perfect as it is possible for the best skill and brains to make them. If the light companies would require proper and reasonable guarantees in this direction, whenever they do supply power, it would not only be a surety for their own protection, but would be a strong inducement for the very best of construction work. The railroad man should see that it is for his interests, since there is nothing that will consume profits so rapidly as break-downs.

There are some 1,600 central electric light stations already located throughout the country, and some 425 railroad companies that, sooner or later, will have to have electric power. Is there any reason why you should not do it? I know of many a station that has to stint and save to tide over the year's dull seasons. You have no day circuits; are held by the sun to one schedule, and by the moon to another. The municipal authorities jump at you from behind one post, and your commercial customers from behind the next. You cannot afford to lose anything. Here is an opportunity for still one more chance at profit. If necessary, enlarge the scope of your charters. It will pay you. Your securities will be worth more, and can be more easily and satisfactorily placed. Railroads have an older and better standing in the financial world and on the money market than electric light companies. Can you afford to let the opportunity go by? From careful research, my own judgment would be that in many cases it would be a lighting company's salvation. I believe the time is rapidly coming when great electric stations, from 5,000 to 20,000 h. p., are to be established.

"New occasions teach new duties, time makes ancient good uncouth." The horse is uncouth. Electricity is our life.

The President—The paper of Mr. Mansfield is before you for discussion.

Mr. Phelps—I would like to ask Mr. Mansfield a question. He gave us some very interesting and somewhat surprising figures as to the relative magnitude of street car traffic and of the railroad traffic of the country on steam roads. They are most extraordinary, and very impressive as to the future of electric railroading. But I would like to ask him if he has made the comparison as to the number of passengers carried *per mile* between the steam railways and horse cars—the difference between the number of passengers carried per mile.

Mr. Mansfield—I attempted to make that division, but could not, because it is such a difficult thing to get at the mileage of horse cars on the various roads in the country and distances carried. The passengers get on and ride two blocks and then get off. It is such a difficult thing that I could not get any correct figures.

Professor E. P. Roberts, recently of Cornell University, now with the Brush Electric Co., then read a paper on "The Electrical Transmission of Power," consisting of notes, illustrated by diagrams, on tests made a few days previous to the convention of a Brush constant current motor and dynamo, in the shop of the Brush company at Cleveland.

Incidentally, Professor Roberts called attention to the remarkable power plant on the Comstock lode, Virginia City, Nev., where six 120-h. p. generators operate six 80-h. p. motors. Each generator drives one motor, and each generator is driven by a Pelton water wheel placed upon the shaft of the dynamo. The wheels are actuated by water falling 1,680 feet, giving a pressure of 700 pounds to the square inch. Each wheel is controlled by a governor designed by Mr. W. B. Devereaux and his brother, Mr. J. H. Devereaux, of Aspen, Colo. The generators run at 900 revolutions, all are independently driven, and the motors turn 850 revolutions per minute, and all drive to the same shaft. An interesting feature is that to this same shaft is geared a surface water wheel and the water which actuates it, after pass-

ing it, drops one-third of a mile, and in losing the potential energy it had at the power house it develops dynamic energy by two transformations back of the same point, and adds it to the small amount of dynamic energy it there developed. A case of poetical justice has occurred in this line. The large Calumet and Hecla mines are about to erect five of these motors to assist in the production of copper, and thus electricity will assist to mine its chief servant, copper, as well as, in many cases, to refine it.

Continuing, Professor Roberts showed the peculiar flexibility of the Brush type of machine and its adaptability to methods of regulation. The motor tested gave 84 per cent. efficiency at 70 brake h. p.; at 80 h. p. (the limit) it would have been somewhat higher. The efficiency must drop at lower powers, as the loss should be about a constant one. He did not have time to obtain figures upon this point. The dynamo efficiency he could not give, as he had no dynamometer of sufficient size available. Professor Silvanus P. Thompson points out that it is higher than with the motor, as in a motor armature. Foucault currents are assisted by the current in the armature, and in a dynamo the reverse is true. The striking points in the system are:—A generator of great power, which cannot be injured by a short circuit; a motor which will not burn up if overloaded, but will stop working. The producer of current, therefore, is not called upon for twice the power represented as being used and for which the motor was sold, and then have to repair the motor to keep the trade. The system being a series one, every device in the circuit which utilizes the current adds to the efficiency of the system, as it decreases the percentage of loss in the wires.

The nominating committee through its president, Mr. Morrison, then made the following report:—

We recommend Kansas City as the next place of meeting of the National Electric Light Association. We recommend further for the officers of the executive committee of the association the following-named gentlemen:—G. W. Hart, Kansas City, chairman; L. A. Beebe, Hutchinson, Kan.; J. A. Corby, St. Joseph, Mo.; B. E. Sunny, Chicago, Ill.; S. S. Leonard, Minneapolis, Minn.; C. R. Faben, Toledo, O.; P. H. Alexander, of New York; Frank Ridlon, of Boston; J. F. Morrison, of Baltimore. The vote was unanimous in the committee, except on the last named.

Mr. Lynch—I move that we adopt the report.

Mr. Whipple—I have the honor, as well as the pleasure, to represent a city something like 12 or 15 hours' ride this side of Kansas City, namely, St. Louis. I am authorized by the board of directors of the St. Louis exposition, to invite this association to hold their next convention in their building in February next. They have unlimited facilities there for the purpose, and those facilities they offer to this convention free of cost. The facilities consist of something like 2,000 h. p., and plenty of space and music halls in which to hold the meetings. I move to amend the resolution by substituting the word "St. Louis" for "Kansas City."

The motion was seconded.

Mr. Morrison—It is proper, that I, as chairman, should give you the reasons which influenced the committee in their recommendation. Mr. Whipple presented to the committee precisely the statement that he has given you, perhaps fuller, and the inducements to recommend St. Louis were so apparent that we were compelled to make further inquiry as to what would be the counter-inducements for Kansas City. Kansas City we thought of for two or three years past, and accepted as the meeting place of the convention at a date to be named by President Weeks, when that city should be able to entertain and provide for the comfort and necessities of the convention. St. Louis offered the exposition building, probably one of the finest and best equipped establishments of that kind in the country, for holding just such meetings as we anticipate the next meeting of the association will be. They give you a meeting hall and 2,000 h. p. steam power.

Kansas City presents its case, first in a telegram from the mayor addressed to the president of the association, in which he says: "I extend through you an invitation to the convention to hold their next meeting here. Exert every effort to bring the convention to Kansas City. Signed Joseph J. Davenport, Mayor." The conditions upon which we are invited to Kansas City are similar to those offered by St. Louis. The committee's judgment was influenced by one or two particulars which I will now mention. The hotel rate for this convention would be from $2.50 to $4 a day, which is very much lower than the regular rates in hotels said to be the finest in the United States; one of four large halls, capable of accommodating 500 or 600 people; power sufficient to drive any exhibit that may be placed there, not steam power but electric power, from any class of current or any system that the gentlemen may desire to use; constant current, alternating currents, the Edison system, the Brush system, and I don't know what others—all this, free of cost.

At St. Louis we learn that the exposition building is some distance from the hotel. At Kansas City the exposition building and the meeting rooms are directly across from one of the hotels and diagonally across from the other. The proposition made by President Weeks is to this effect: That one hall shall be taken for the meeting room and one for the exhibition room. That the exhibition room shall be closed during meeting hours and open all the rest of the day.

Mr. Whipple—I did not intend to speak twice; but as telegrams are in order, I would like to read one from the president of the board of directors of the St. Louis exposition. Here is the despatch: "Our board of directors have instructed me to invite the National Electric Light Association to hold their February convention in our building. We have all the necessary facilities for the meeting, and our citizens will extend to the members of such convention every possible courtesy. Signed, Samuel M. Bernard, President." In relation to the location, let me say that the exposition building is just four blocks from the post office.

The President—The question is on the amendment of Mr. Whipple to substitute St. Louis for Kansas City in the report of Mr. Morrison.

The chairman being unable to declare the result of a *viva voce* vote, a rising vote was called for, ; and there appeared to be 14 in favor of the amendment, 13 opposed to it.

A recount was called for by Mr. Morrison.

On taking a rising vote the second time, there were counted 19 in favor of the amendment and 11 opposed to it.

The President—The ayes have it.

Mr. Morrison—Now, Mr. President, before a decision is rendered in this case I want you to make one other decision—that is, whether we are operating under the new constitution or under the old one.

The President—Under the new constitution.

Mr. Morrison—Then the vote had now is null and void, because the vote should be confined to active members.

Mr. Reed—Mr. Morrison himself has stated this constitution could not go into effect until February next.

Mr. Morrison—I have not. Many points about it do not meet with my approval. This convention to-day is a convention of supply men and not of central station men. But if you are acting under the new constitution the vote must be that of the central station men and does not include the supply men. At the Chicago convention you stood upon the eve of a disruption, and it is for that reason that I have risen here. I came here for a peaceful solution of these questions. These supply men were recognized in the appointment of a committee for the revision of the constitution. That report has been unanimously accepted by the association, and it limits the voting power of the association to the central station men. You adopted that constitution, and you are the men whom it affects. I would not have objected to the supply men as members. I would have taken my chances with you. Under the constitution which you have adopted, there is not a single man who stood up there among that gallant band of 19 who has a right to vote on this question. I call for the Chair to make a decision in this case. If he decides that your action is null and void, the vote will have to be decided by the central station men. When you make laws, I insist that you shall abide by the provisions of those laws; when you adopt a constitution, I insist that you shall live up to that constitution. You did not even give Mr. Lynch the opportunity of taking up your constitution *seriatim*. You could then have made the changes you desire; you could have done the same thing that you are talking about now. You shut the door yourself. After you have made a bargain (and I have known many of you to make bad bargains and stand by them, filling contracts with me for wire after the price had advanced), you should stand by it.

Mr. H. A. Reed—I have no choice at all between these two cities. I would just as lief go to one as to the other. The question that I would like to ask is as to whether the president decided that this constitution is binding upon this association at this time, at the moment of the acceptance—not the adoption—where no chance was given for discussion upon this important subject; and if we people are kicked out and told, "We will take your brains and your money, but we do not want your vote," I want to know whether that is admitted now, or whether it does not take effect until next year, as Mr. Morrison himself decided yesterday it would.

Mr. Morrison—Mr. President, allow me to say that we have not kicked the gentleman out. We have not done anything of that kind. We all want to keep you in. You have kicked yourselves out. You adopted the constitution which bars you out.

Mr. Reed—Excuse me, but there has been no adoption here yet.

Mr. Morrison—A play upon words, Mr. Reed. You simply took the other word, which means the same thing. I believe that that constitution was the work of the supply men. Their vote said it was acceptable, and they unanimously adopted or accepted it, and they have made it the fundamental law. The Chair has declared that we are operating under the provisions of this constitution.

The President—I greatly regret that this discussion has arisen, as I took this whole movement in the kindest spirit, as originating among those members of the association who are most affected by the proposed action, and the committee who submitted this amendment—three of them belong to that class, the

chairman, Dr. Moses, Captain Candee and Mr. H. D. Stanley—and these sentiments that have been expressed upon the floor of this convention surprise me and pain me more than I can express. But as I am called upon by the gentleman from Baltimore to decide the point raised by him, I must do what I consider my duty, and I decide that the point raised by him is well taken. This report was submitted to this convention. An opportunity was given for discussion and amendment. It was moved to accept. This was carried, and the decision of the Chair is that this is the constitution of the National Electric Light Association.

Mr. Whipple—I entered into a contract with this association last February, and paid $20 for certain privileges. What right has this association to violate that contract?

Mr. J. W. Godfrey—I voted with the understanding that the report was to be received, which was the word that Mr. Brown used.

Mr. Brown—I used the word "accept" and used it understandingly. The chairman made the correction, and stated the question correctly. I just wish to put Mr. Whipple and the others right.

Mr. Lynch appealed from the decision of the Chair that the new constitution takes effect at once. It was seconded by Mr. Blackwell, of Vermont.

Mr. Candee—I am one of that unfortunate committee now raked over the coals, and while I think this discussion is entirely out of order, I want to say that every member of the association has received a circular regarding the constitution. We received answers to 105, 71 being in favor of the constitution adopted. It was not one of our own make, but that of a majority of the letters received. Outside of that there are no amendments, and nothing additional or new. We thought that we were simply expressing the opinion of the association, and of the supply and central station men.

Mr. Morrison—I call for the regular order of business, and the vote as provided by the constitution on the question of the next place of meeting.

Mr. Lynch—I object. There is a motion before the house.

The President—I understood Mr. Lynch to withdraw that motion.

Mr. Lynch—No, sir; I did not withdraw it.

At this juncture, the president requested Mr. Morrison to take the chair.

After taking the chair, Mr. Morrison inquired for the gavel.

The Chairman—What is the business now before this association?

Mr. Lynch—The question is upon the appeal from the president's ruling declaring the new constitution in force from the moment of its acceptance.

The Chairman—The appeal from the decision of the Chair is not in order. The constitution is adopted. Mr. Secretary what is the next regular business before the association?

The Secretary—Mr. Chairman, there is no business in the hands of the secretary as far as he knows—there is no next order of business.

The Chairman—We will proceed then with the adoption of the report of the committee. Are you ready for the question?

The Chair put the question and declared it carried, and the report adopted.

Calls for division.

The Chairman—The decision of the question is made, and no division can be called for after that. As there is no regular business before the association, there is nothing left to do but to entertain a motion to adjourn.

The motion to adjourn was put, seconded and carried, and the Chairman declared the convention adjourned *sine die*.

REPORT OF THE EXECUTIVE COMMITTEE.

* * * * * * * * *

The following is from the executive committee's report. The financial portion is omitted being substantially a repetition of the treasurer's report.

One of the most important matters before the committee was the establishment of a permanent head-quarters in the City of New York The experiment has been tried a few months, and at the Chicago convention it was ordered to be continued six months more. Your committee have moved the office from 23d street to the elegant telephone building No. 18 Cortlandt street, in the centre of the electrical business district, and convenient for both resident and non-resident members.

The work done by the secretary at this office shows itself in the largely increased membership of the association, and in the work of the various committees which have reported at this convention. The committee have no hesitation in saying that the success of a permanent head-quarters has been in advance of their expectations, and earnestly recommend that the New York office be continued.

The volume of proceedings of the Chicago convention has been made up in better form than heretofore, and the cloth binding changes the pamphlet, which may be thrown into the waste basket, to a book worthy a place in any library. * * *

Your committee are glad to be able to present a good report as to the finances of the association. The year 1888 closed with a debt of $1,800. The debt has been entirely wiped out, with the single exception hereinafter referred to. The entire expense of the current year to August 1 has been paid. There are no outstanding bills, and a balance remains in the treasurer's hands of $910. The income of the association for the calendar year will be over $5,200; the expenses about $1,000 less. So that your committee can say with some confidence and much satisfaction, that the association is in a sound financial condition. There is, as just mentioned, one claim against the association still unpaid. The amount is $259.60. This was incurred before the appointment of this committee, therefore the payment is considered beyond its jurisdiction. There is no doubt whatever that it was incurred for the benefit of the association, and your committee recommend that authority be given them for its payment. * * *

The following resolution has been approved and adopted by the executive committee:—

We, the undersigned, a sub-committee of the executive committee, appointed for the purpose, beg leave to report the following, as embodying the views of the executive committee:—

WHEREAS, It is extremely important that the United States census for 1890 should contain a special section for the electrical industry, and that the data for such section should be collected, tabulated and published in a thorough and systematic manner,

Resolved, That the National Electric Light Association, now in convention, respectfully request the superintendent of the United States Census for 1890 to provide a section for the electric industry, and they would suggest that Mr. Allen R. Foote, of Cincinnati, Ohio, has proved himself to be well qualified to do this work, and that he would be a proper person to organize and direct it.

(Signed) EDWIN R. WEEKS,
OTTO A. MOSES,
T. CARPENTER SMITH.

CONCERNING THE ADOPTION OF THE NEW CONSTITUTION OF THE ELECTRIC LIGHT ASSOCIATION.

President Weeks sends us the following letter:—

To the Editor of THE ELECTRICAL ENGINEER:—

As objections have been raised to certain rulings of the Chair at the recent convention of the National Electric Light Association, and as some have even stated that legislation was intentionally hasty and unfair, it seems proper to analyze the rulings in question to show that the decisions were, in all important particulars, in strict accord with parliamentary law.

No subject ever brought before the association has been more generally and perfectly understood than was the report of the committee on amendments to the constitution. Every member had, by means of circular letters, been given an opportunity during the past six months to express his views as to the needed changes. The replies received by the committee were almost unanimously in favor of the amendments as adopted.

These amendments were submitted to the convention article by article on the first day of meeting, and were made a special order of business for the third. Copies of the proposed amendments and also of the old constitution were distributed.

By reference to the minutes of Thursday's proceedings, it will be seen that after the re-reading of the amendments, a motion was made and seconded to accept the report of the committee. According to the parliamentary law, *to accept* is to adopt (see Cushing, chap. xv., sec. iv., par. 295); and the mover in this case, an associate member, stated to the convention that he used "accept" understandingly, and that the chairman put the question correctly. Therefore when the motion prevailed, the new constitution became the organic law of the association and the chairman was obliged to decide in accordance therewith.

An objection that the votes upon which it was carried were not counted to determine a two-thirds majority would have been valid. But as the *viva voce* vote was unanimous, the point did not occur to the Chair; and as no objection was made until long after the result had been announced and the house had proceeded to other business, it could not then be in order.

The idea of taking up the amendments *seriatim* was good, but it was presented in the form of a suggestion which was not accepted by the mover of the question under consideration. Even in the form of a motion, it would have been out of order, as a motion was already before the house.

A motion for reconsideration was made, but as it came from one who admitted that he had not voted on the original motion, by parliamentary usage it was not in order. (See Cushing, chap. xiv., par. 257.) The immediate presentation and seconding of a new motion prevented all further discussion of the previous question.

The point is raised that the decision of the Chair deprived of franchise those who had paid dues for the present calendar year. This objection overlooks the fact that the associate members were seeking to control legislation providing for a meeting to be held nearly two months after the close of the calendar year, and therefore entirely beyond their jurisdiction, even had the amendments been formally accepted as taking effect at the expiration of the current year. Had this phase of the question occurred to the associate members, I am confident, in view of the generosity which they evinced in originating and carrying on the whole amendatory movement, that the feeling would have been quite different.

From the foregoing, it appears that the efforts of remonstrants were ineffectual through their own unparliamentary procedure; not through unfair or illegal decisions.

When the excitement of the moment has passed, it must be recognized that the decisions were not only strictly legal, but just; and all will see that their interests still lie with the National Electric Light Association.

EDWIN R. WEEKS.

Kansas City, Mo., Aug. 16, 1889.

The following is from the *Electrical Review*, August 24:—

President Weeks, of the National Electric Light Association, undertakes to explain his action at Niagara Falls, in a communication to the *Review* He builds two or three men of musty straw and with much self applause knocks them down, and then proceeds with an argument that makes one think of that old definition of thunder which describes it as "a loud noise heard by people not deaf." Mr. Weeks's evasive defense is that all he did was in "strict accord with parliamentary law." Does he explain the decisions of his assistant presiding officer, against which he did not protest, on the same ground? Was it "parliamentary law" for Mr. Weeks to decide one day that legislation was legal which he had declared the day previous would be illegal? Mr. Weeks, the members of the National Electric Light Association do not care for your opinion on "parliamentary law." They know when they have received proper treatment from a presiding officer, and the sentiment comes to the *Review* from all

quarters, and with unmistakable emphasis, that you acted the part of an inconsistent and unjust presiding officer and resorted to trickery to secure personal ends.

You were wrong in putting the motion to "accept" under your interpretation of its meaning, and, besides, you had stated the day before that such action "could not" be taken; you were wrong in all equity and justice in deciding that this motion *adopted* the constitution, and you were most selfishly wrong in deciding that the constitution thus adopted took effect at the moment it was to your personal advantage to so decide. Then was the time for you to have been broad enough and wise enough to have respected the rights of your peers on the floor of the convention.

AN OPEN LETTER TO THE MEMBERS OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

I am not surprised that the electrical journal which has, for some time past, been conspicuous for its lagging pace, should have found my communication of the 16th inst. "so shallow" as to require further consideration before publication; but no one who prides himself upon his "journalistic manhood" should intentionally misquote.

It may not now be out of place to set before those who wish to form a correct judgment of the conduct of the association, a fact which will perhaps explain the animus of the recent personal attacks, and show that the attempt to use the association for personal ends did not come from your president.

Prior to the reception of the report of the committee on nominations and place of meeting, and after the names suggested for the next executive committee had become known, a member of the association having a grievance against one of the nominees, protested against his preferment, and *advised* me that unless his name was stricken from the list, the next convention would be held in St. Louis. I declined to interfere; answering that I saw no connection between the nomination of the gentleman in question and the place of meeting, and informing him that the whole matter was in the hands of the nominating committee, and must be passed upon by the association in convention. Confident that the large majority of our members do not favor moving the association through political wire workers, or prostituting it to personal gain or the punishment of personal enemies; I feel sure that had I chosen to take the floor and by descending to personalities sacrifice the feelings of a few, the first vote on the meeting place would have been different.

I am charged with inconsistency in that upon one day I said, "We certainly could not legislate members out of the association," and upon the next but one decided that the new constitution was adopted. I still maintain that central station men could not vote associate members out of the association. But when such movement originated with the associate members, when the motion to accept came from an associate member, when the motion was carried unanimously by a house at least two thirds associate, and was immediately followed by a motion made and seconded by associate members, to appoint a committee on by-laws, all charge of inconsistency must fall. Had the proportion of active and associate members been reversed, and had the motions above referred to come from active members and been carried by them notwithstanding the protests of associate members, the charge of inconsistency would be just.

I will pass the statement that I have used the association for my personal advantage with the observation that the decision upon the adoption of the new constitution was first made upon a question foreign to the place of meeting, and that the movement to convene in Kansas City did not originate with me, nor can a convention there held, in any way assist my private fortune or those of the companies which I represent. We have no advertising or subscription lists to maintain, or chattels of any kind to sell. Mr. Rhodes, Mr. Gilbert, Mr. De Camp, Mr. Morrison, or any of the purely central station men who have entertained the association, will doubtless testify that the balance is heavily against profit and loss.

My action in relinquishing the chair on appeal from my decision seems to have been generally misunderstood. While I might have retained it by parliamentary rule, I chose to follow custom and at the same time avoid deciding against a personal friend. Knowing that the work of the convention was not complete, I expected to resume the chair after the decision upon the appeal. As I could not hear the conversation between the chairman and the secretary as to the next order of business, nor the motion to adjourn, no one could have been more surprised than I at the abrupt adjournment. Far from being indifferent, I refused to recognize it as *sine die*, until forced to do so by the record of the secretary, and by parliamentary law.

In conclusion, I would suggest that the interests of the association cannot be furthered by personal attacks or by general charges unsustained by proof of record. My only desire is that the facts as shown by the secretary's minutes shall be the basis of judgment upon the work of the Niagara convention.

EDWIN R. WEEKS, *President*.

Kansas City, Mo., Aug. 28, 1889.

COLLEGE NOTES.

Pennsylvania State College.

The *Electrotechnic Course* in the Pennsylvania State College was established by the trustees early in 1887, although for several years before that date students who so desired had done much more than the usual undergraduate work in electrical studies and laboratory practice.

The legislature of the state, in 1887, made an appropriation to the college for new buildings, and in designing the Physics building provision was made for the work of the electrotechnic course. The building is just approaching completion, and is to be furnished and occupied at the opening of the fall session, 1889.

This building has a front of 84 feet, and a depth part of 42 feet and part of 62 feet. There are a well lighted basement (floor but three feet below surface), first and second stories, and some valuable attic rooms. The first floor has shop, battery room, gasometer room, constant temperature room, engine room, large dynamo-electric laboratory, four small laboratories, photometer room, spectrometer room, and clock room. On the second floor are the lecture room, apparatus room, library and drawing room, office and four special laboratories. On the third floor are a large elementary laboratory, an apparatus room, an assistant's room, photographic laboratory and dark room, optical laboratory and copying room.

The lecture room, on second floor, 39 by 35 feet, is without columns, and is 18 feet high. The space back of it is divided into two stories, about 9 and 8 feet high. Thus the apparatus room is two stories high, a lift running past it from basement to attic. The remainder of this space is to have facilities for drying the air in any weather for work in static electricity, and to be used when needed as a section recitation room. It is reached by a short stair from the student's entrance to the lecture room. This entrance is on a level with the highest platform of the raised seats.

The first floor is a heavy grouting of broken stone, covered with granolith; instruments may be placed anywhere on it with perfect steadiness.

The lighting, availability of light for experiment, water supply, supply of gases, ironless room for magnetic work, masonry piers for instruments in basement and first story, ventilation, etc., have all been carefully studied.

The building is designed for instruction by recitations and lectures; by elementary laboratory work, a class working under an instructor; and by advanced laboratory work, qualified students working on special subjects or original investigations alone in the small laboratories.

The course of study and practice covers four years and entitles to the degree of B. S. in electrotechnics (the college does not give the degree of engineer in any course at graduation, only B. S. in one or other line), and of electrical engineer after a year of advanced study.

The leading studies of the course are mathematics, physics, drawing and shop work, such studies from the civil and mechanical engineering courses as are most important to the electrical engineer, and especially the theory and the technical applications of electricity. The mechanical and physical laboratory work are extensive and of great value for the work in the electrotechnic laboratory. The latter work is designed to give the student a working familiarity with the electric and magnetic magnitudes and their units, and with measurements and instruments; and to give him as much as possible of practice in those problems connected with the use of the steam engine, dynamos, electric motors, distribution of currents, transmission of energy, photometry, etc., that will engage him in his actual electro-technical work.

GAS ENGINES IN ELECTRIC SERVICE.

At the close of last year, we learn from one of our foreign exchanges, there existed in the City of Munich alone about 116 electric light installations, numbering 588 arc lamps and 23,231 incandescent lamps. The Theatre Royal, in the same city, alone employed 4,900 of these lamps. Allowing for each arc lamp a mean intensity of 900 c. p. and for each incandescent lamp an intensity of 16 c. p. we have here a total of 900,896 c. p. Turning now to the motive power spent in operating these lights, we find that 256 arc lamps and 6,687 incandescent lamps are produced by Otto gas engines; 233 arc lamps and 14,610 incandescent lamps are produced by steam engines; and 90 arc lamps and 1,934 incandescent lamps are operated by turbines. The total number of candles represented by these lamps can thus be divided up with special reference to the power used:—

	Arc.	Incandescent.	Total.
Gas engines...........	230,400	106,992	337,392
Steam engines.........	209,700	233,760	443,460
Turbines............ ..	89,100	30,944	120,044

By way of comparison, it should be stated that at the close of the year 1885, the total of electric lights in use in the City of Munich did not exceed 160,020 c. p. We commend a study of these facts to our American gas companies.—*Practical Electricity.*

A NEW ELECTRIC RAILWAY COMPANY.

The Short Electric Railway Co. has been incorporated with a capital of $1,000,000, under the laws of Michigan, and is a Cleveland enterprise. The poles, line appliances, trucks and motors for the electric street cars, which they will supply, will be manufactured in Cleveland, and the head quarters of the company will be at the office of the Brush Electric Co., in that city. On July 26, the stockholders met in Cleveland and elected the following directors: S. H. Short, G. W. Stockly, C. F. Brush, J. J. Tracy, J. Potter, W. W. Leggett and N. B. Abbott. Mr. Leggett resides in Detroit, and Mr. Abbott's home is in Columbus. The other directors are residents of Cleveland. The first meeting of the board of directors was held in the office of the Brush Electric Co., when S. H. Short was elected president and general manager; J. Potter, vice-president, and W. W. Leggett, secretary and treasurer.

Mr. Potter is reported in the Cleveland *Leader* as making the following statements concerning the organization and plans of the new company: "The idea of the Brush Electric Co.," said Mr. Potter, "in securing control of the Short railway system, which we consider the best in the country, was to take advantage of the business it offered, and to open up the large market which exists for the sale of electric generators and motors. The new company has large contracts on hand and is negotiating for others. We have commenced operations and expect to do a very heavy business this fall. The new company acquired the business

of S. H. Short & Co., of Columbus, O., who controlled the Short inventions." The same paper quotes Mr. Short as follows, concerning his system: "It differs from all other electric railway systems in that we use two wires overhead. These two wires are cut into sections so arranged that each section receives power only for operating the cars upon it. If there is no car on any one section there is no power in the wires of that section to injure persons or animals. There is no electricity on the rail, as I consider that dangerous to life and property. A fallen wire can be handled without receiving a shock. In St. Louis our cars are running 20 hours a day, covering 120 miles each, and the armatures and magnets never burn out. In Huntington we have a road paying 20 per cent. on the capital invested. We have a great advantage in the use of the Brush motors and generators. These appliances have lately been devised by Mr. Brush for street railway work and are entirely new to the electrical fraternity."

Mr. Short was early in the field of electric traction, and has accumulated an experience that will doubtless lead to important results in his new connection.

INTERNATIONAL ELECTRICAL CONVENTION FOR 1892.

At the meeting of the Council of the American Institute of Electrical Engineers, held in New York August 6th, a resolution was adopted for the appointment of a committee of five, to be appointed by the president, to formulate a plan of organization for an international electrical convention, to be held in this country during the season of the World's Fair of 1892. At the meeting of council, Aug. 14th, the committee was enlarged to 15, and its work more specifically defined. The secretary was instructed to communicate at once with President Mascart, of the electrical conference at Paris, informing him of the action of the Institute, and suggesting that the work of the present conference be taken up at the proposed convention of 1892.

In accordance with previous action of the council, the following delegates were appointed to participate in the Paris conference, all of whom are now in France: Thomas A. Edison, Carl Hering, E. Wilbur Rice, Jr., Joseph Wetzler, and Nikola Tesla.

Vice-president Francis R. Upton, of the Institute, has also been requested to use his influence to secure, if possible, the official sanction of an adjournment of the conference to meet in this country in 1892. President Elihu Thomson will shortly announce his appointments on the committee of 15, and the work of organization will be taken up immediately. The various electrical organizations of the country will be invited to co-operate.

MANUFACTURING AND TRADE NOTES.

THE RHODES AND KEESE ELECTRIC CO., of Los Angeles, has obtained the contract for furnishing the Redondo Beach Hotel throughout with electric lighting and other apparatus, costing something over $10,000. The Rhodes and Keese company is made up of Messrs. S. J. Keese, T. H. Rhodes, W. I. Keese, J. F. Cosby and G. Wiley Wells, with the Southern California bank as treasurer. Mr. S. J. Keese is president. He has been the agent of the Thomson-Houston Electric Co. in that section, and organized the Pasadena Electric Light Co. Mr. T. H. Rhodes's reputation as an electrician is well known throughout Southern California.

THE HILL CLUTCH WORKS, through their eastern manager, Mr Walter C. Wonham, 18 Cortlandt street, New York, report that they have just completed the installation of very large outfits of clutches and power transmission machinery for the Buffalo Electric Light and Power Co.; the Mount Morris Electric Light Co., New York; the New Bedford Gas Light Co., New Bedford, Mass.; Salem (Mass.) Electric Light Co.; and are now putting in foundations for machinery to be erected in the Jersey City Electric Light Co.'s new station, and the Fitchburg (Mass.) Gas Co.

Mr. Wonham states that business is good with them and is increasing constantly. In fact, they are taxed to the utmost with work, but, like Oliver Twist, are not satisfied, and still hold out their bowl for more.

MR. BENJAMIN F. KEELEY, 91 Liberty street, N. Y., is agent for the Berryman feed water heater—of which over 12,000 are said to be now in use—and also for Maypole's exhaust pipe head for non-condensing engines.

IT is a pleasure to note the success of the Wright Electrical Engineering Co., consulting and contracting engineers, Boston, Mass., of which Mr. Frank Ridlon is president; Mr. A. P. Wright, managing director; and Mr. C. H. Herrick, secretary. Mr. Wright, the engineer of the company, has made a record in his former connection with the Westinghouse Electric Co., and later in charge of the electric light station at Springfield, Mass., entitling him to the confidence of investors in electric plants in his ability to serve their interests.

JOHN A. ROEBLING'S SONS CO., Trenton, N. J., issue a very complete list of bare and insulated electric wires, dated August 1. 1889. This old house has for some years been amplifying the range of its products for electric service, till now it covers conductors of all classes, various line wires for different uses, and flexible conductors for electrical apparatus.

THE ANTI-FRICTION METAL CO., manufacturers of tempered copper boxes for high speed electric machinery, and bearings of every kind, North East, Penn., send us their announcement calling attention to the merits of their tempered copper boxes, which. after two years experience on railroads, they confidently offer to the users of all high speed machinery. Their pamphlet contains several valuable testimonials to the merits of their products.

THE THOMSON-HOUSTON ELECTRIC CO. reports the following sales of central station lighting plants:—Incandescent—Springfield, Ohio, 1,300; Paterson, N. J., 650; Lee, Mass., 650; Memphis, Tenn., 1,300; Palmer, Mass., 650; Eufaula, Ala., Great Falls. N. H., 200; Portsmouth, N. H., 500; Natick, Mass., 1,300; Bellaire, O., 70; Athens, O., 50; St. Joseph, Mo., 100; Canandaigua, N. Y., 650; Citizens Co., Brooklyn, N. Y., 135; Chattanooga, Tenn., 100; Baltimore, Md., 1,000; also, Brunswick, Ga., 50 arc; Nantucket, Mass., 18 arc, 500 incandescent; Catskill, N. Y., 650 incandescent, 30 arc; Montclair, N. J., 30 arc, 1,300 incandescent. Also, the following isolated plants:—Julius Saul, Albany, N. Y., 20 arc, 100 incandescent; Providence Steam Engine Co., Providence, R. I., 30 arc; Spencer House, Niagara Falls, 200 incandescent; Rodman Manufacturing Co., Lafayette, R. I., 800 incandescent; Bennett Manufacturing Co., New Bedford, Mass. 800 incandescent.

MESSRS. ROLAND T. OAKES & CO. have the contract for putting in 213 incandescent lights in the Holyoke House, Holyoke, Mass., and are also to do the construction work on 600 incandescent lights for the works of the Far Alpaca Co.

THE City of Chicago has contracted with A. L. Ide & Son, of Springfield, Ills., for engines and boilers for four power plants of 500 h. p. each, one to be located in each district, for lighting the streets with 2,000 arc lights of 2,000 c. p. each. Sixteen Ideal engines of 125 h. p. each will be required.

MR. THEODORE ALTENEDOR, Philadelphia, under the title, *Points about Drawing Instruments*, issues a pamphlet of 36 pages, illustrated, setting forth some significant points touching the importance of the quality of the tools used by the professional draughtsman. If a genius can do good work with poor tools, the average man can not; and the exceptionally clever are always spared much unnecessary labor by having perfect implements at hand. Mr. Altenedor offers a line of drawing instruments which he confidently claims to possess an unusually high degree of accuracy and reliability.

THE WENSTROM NORTHERN ELECTRIC CO., 5 Dey street, are introducing a new design of iron-clad dynamo. Mr. B. Blum is general manager of the new company.

THE HUSSEY BATTERY CO. has been incorporated to take over the patents, and to manufacture all the patents, of Mr. A. C. Hussey relating to primary batteries.

THE CLARK ELECTRIC CO. have moved their head-quarters to New York city, and have opened an office in the Corbin building. at John street and Broadway.

THE HEISLER ELECTRIC LIGHT CO., of St. Louis, have been awarded the contract for furnishing 500 30 c. p. incandescent lights to the St. Louis Exposition and Music Hall Association for use during the exposition season this fall. The Heisler company is furnishing a complete set of apparatus for this display in the Universal Electrical Exhibition. This plant, in addition to supplying the exposition with the lights above referred to, will have sufficient surplus to fully illustrate the adaptability of the Heisler system for distributing incandescent lights from central stations over wide areas. The Heisler company report the successful starting of central stations at San Marcos, Tex., and Marseilles, Ill. The principal lighting done by the latter company is in Ottawa, 8½ miles distant, one of the circuits being 34 miles in length.

Foreign.

Great Britain.—MR. RANKIN KENNEDY has transferred his patents and inventions in electrical engineering, together with his business formerly carried on at Woodside Electric Works, Glasgow, to the firm of M'Culloch, Sons & Kennedy (limited), Vulcan Works, Kilmarnock.

At these works the well-known single bobbin dynamos ironclad alternators, transformers, high-speed steam engines, complete ship lighting plants, central station plants, arc lamps, high candle-power incandescent lamps, and other specialties (formerly supplied and manufactured at the Woodside Electric Works, Glasgow), are now made and supplied solely by the new company.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Allegheny, Pa	Obs'rvat'y Hill Pass.Ry.Co.	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co	2	3	Thomson-Houston.
Ansonia, Conn.	Derby Horse Ry. Co	4	1	Thomson-Houston.
Appleton, Wis.	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J.	Seashore Electric Ry. Co	4	20	Daft.
Asheville, N. C.	Asheville Street Railway	3.5	4	Sprague.
Atlantic City, N. J.	Pennsylvania R. R. Co	6.5	6	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Bangor, Me	Bangor Street Railway Co	5	4	Thomson-Houston.
Bay Ridge, Md	Bay Ridge Electric R. R	2	2	Sprague.
Binghamton, N. Y.	Washington St., Asylum & Park R. R.	5	8	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., Brookline Branch	11	23	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	20	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co	4	4	Sprague.
Buffalo, N. Y.	Buffalo, St. Ry. Co	2.5	4	Sprague.
Carbondale, Penn	Carbondale and Jermyn Street Railway	1.5	3	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	3	Daft.
Cincinnati, O	Cinc. & Inclined Plane Ry	6	20	Sprague.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cleveland, Ohio	East Cleveland Railroad Co.	8	16	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	10	10	Thomson-Houston.
Cleveland, O	Collamer Line, East Cleveland, O	3	8	Sprague.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co	1	1	Thomson-Houston.
Davenport, Iowa	Davenp'rt Cent. St. Ry. Co	3.5	9	Sprague.
Danville, Va.	Danville St. C. Co	2	4	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co	9	12	Van Depoele.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	10	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Eau Claire, Wis	Eau Claire St. Ry	5	6	Sprague.
Erie, Pa	Erie City Pass. R. R. Co	12	20	Sprague.
Fort Gratiot, Mich	Gratiot Electric Railway	2	2	Van Depoele.
Harrisburg, Pa	East Har'sb'rg Pass. Ry.Co.	7.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	4	Sprague.
Ithaca, N. Y.	Ithaca Street Railway Co	1	2	Daft.
Jamaica, N. Y.	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind	Lafayette Street Ry. Co	3	9	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angeles, Cal	Los Angeles Elec. Ry. Co.	5	4	Daft.
Louisville, Ky	Central Pass. R. R. Co	10	10	Thomson-Houston.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)	1	1	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Highland Line)	2	3	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Nahant Line)	.8	1	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Marlboro, Mass	Marlboro St. Ry. Co	3	2	Sprague.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3	6	Thomson Houston.
Newark, N. J	Essex Co. Pass. Ry. Co.	2.5	4	Daft.
New York, N. Y.	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
New Orleans, La			1	Daft m'tr and Gibson st'ge battery.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co	14	14	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	10	26	Thomson-Houston.
Omaha, Neb	Omaha Horse R. R	10	20	Sprague.
Omaha, Neb	Omaha &Co'ncil BluffsR.R.	4	2	Sprague.
Pittsburgh, Pa	Pittsburgh, Knoxville & St. Clair St. Railway	2.25	4	Daft.
Plymouth, Mass	Plym'th & Kingston Ry.Co.	4.5	3	Thomson-Houston.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Reading, Pa	East Reading R. R. Co	2	3	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Revere, Mass. (Ex.)	Revere St. Ry. Co	2.5	5	Thomson-Houston.
Richmond, Va	The Richmond Union Pass. Railway Co	13	46	Sprague.
Rochester, N. Y.	Rochester Electric Ry. Co	7	8	Thomson-Houston.
Salt Lake, Utah	Salt Lake City R. R. Co	6.5	10	Sprague.
Salem, Mass	Naumkeag Street Ry. Co	2	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
Seattle, Wash. Ter	Seattle Electric Railway and Power Co	5	5	Thomson-Houston
St. Catherine's, Ont	St.Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	6	12	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	10	17	Sprague.
St. Joseph, Mo	Wyatt Park Ry. Co. (Northern Division)	4.5	9	Sprague.
St. Louis, Mo	Lindell Ave. R. R	5½	10	Sprague.
Scranton, Pa	The People's Street Ry	12	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	5	10	Thomson-Houston.
Scranton, Pa	Nayang Cross-Town Ry	1.5	3	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Southington, Conn	Southington & Plantsville Ry. Co	2	2	Thomson-Houston.
Syracuse, N. Y.	Third Ward Ry. Co	4	8	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co	2.5	6	Sprague.
Stillwater, Minn	Stillwater Electric St. Ry	5	6	Sprague.
Topeka, Kan	Topeka Rapid Transit Co	17	30	Thomson-Houston.
Washington, D. C.	Eckington & Soldiers'Home Electric Railway Co	3	10	Thomson-Houston.
Wheeling, Va.	Wheeling Railway Co	10	1	Thomson-Houston.

Electric Street Railways in America now in operation.—*Continued.*

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Wichita, Kan	Riverside & Sub'ban Ry.Co.	9	6	Thomson-Houston.
Wichita, Kan	Wichita & Suburban Ry.Co.	7.5	7	Sprague.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	3	7	Sprague.
Wilmington, Del	Wilmington City Ry. Co	3	4	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	2	2	Van Depoele.

Total—Roads 92
" **Miles** 488.25
" **Motor Cars** 731

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Adrian, Mich	Adrian Electric Railway	3		Nat.Elec.Tract.Co.
Akron, O	South Side Extension	6	10	Sprague.
Albany, N. Y	W't'rvliet T'npike&R.R.Co.	15.5	16	Thomson-Houston.
Atlanta, Ga	Atl'nta & Edg'w'dSt.Ry.Co.	4.5	4	Thomson-Houston.
Atlanta, Ga	Fulton Co. St. Ry. Co	9	8	Thomson-Houston.
Attleboro, Mass	No. Attleboro & Wrentham St. Ry. Co	8	5	Thomson Houston.
Americus, Ga	Americus St. Ry. Co	5.5	4	Thomson-Houston.
Auburn, N. Y	Auburn Electric Ry. Co	3	5	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets	230	300	Thomson-Houston.
Cincinnati, O	Cincinnati St. Ry. Co	2.7	8	Thomson-Houston.
Cincinnati, O	Colerain Ave. Ry. Co.	5	8	Thomson-Houston.
Cleveland, O	B'way & Newb'ugh St. Ry.	10	10	Sprague.
Cleveland, O	East Cleveland St. R. R., Prospect St Line	5	3[illegible]	Sprague.
Dallas, Texas	Dallas Rapid Transit R. R.	3	2	Sprague.
Dallas, Texas	West Dallas St. R. R	3	2	Sprague.
Decatur, Ill	Citizen's Electric St. Ry	5	4	Thomson-Houston.
Decatur, Ill	Decatur Electric St. Ry	3		Nat.Elec.Tract.Co.
Detroit, Mich	E. Detroit & Grosse Pointe Ry	8		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit City Railway, Mack Street line	2		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit, Rouge River & Dearborn R. R	1	1	Sprague.
Denver, Col	University Park Ry. & Electric Co	4	8	Thomson-Houston.
Dubuque, Ia	Key City Electric Ry	2	4	Sprague.
Elkhardt, Ind	Citizens Street Railway	7		Nat.Elec.Tract.Co.
Fort Worth, Texas	Fort Worth City Ry. Co	10		Nat.Elec.Tract.Co.
Fort Worth, Texas	FortWorth L'd & St. Ry.Co	15		Nat.Elec.Tract.Co.
Joliet, Ill	Joliet St. Ry	3	4	Thomson-Houston.
Kansas City	No. East St. Ry. Co	7	10	Thomson-Houston.
Kansas City, Mo.	Vine St. Ry	3	6	Thomson-Houston.
Kansas City, Mo	Metropolitan St. Ry. Co	4.5	4	Thomson-Houston.
Laredo, Texas	Laredo City R. R.	4	4	Sprague.
Long Island City, N.Y.	Long Island City & Newton Electric R. R.	3	2	Sprague.
Lynn, Mass	Belt Line Ry. Co	4.5	4	Thomson-Houston.
Lynn, Mass	L. & B. R. R. Myrtle St. Line	3	4	Thomson-Houston.
Moline, Ill	Maline St. R. R	3	2	Sprague.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Nashville, Tenn	Main St. & Lichy Ave. R.R.	2	4	Sprague.
Newburyport, Mass	Newburyport & Amesbury Horse Ry. Co	6	2	Thomson-Houston.
Newton, Mass	Newton Circuit Line	8	10	Thomson-Houston.
Newport, R. I	Newport St. Ry. Co	4.5	6	Thomson-Houston.
New York, N. Y.	North & East River Ry. Co.	3	24	Bentley-Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Ontario, Cal	Ontario & San Antonio Heights Ry. Co	8	4	Daft.
Ottawa, Ill	Ottawa Electric St. Ry. Co	5	8	Thomson-Houston.
Ottumwa, Ia	Ottuma St. Ry. Co	5	4	Thomson-Houston.
Passaic, N. J	Passaic St. Ry	3	3	Thomson-Houston.
Peoria, Ill	Central Ry. Co.	10	15	Thomson-Houston,
Pittsburgh, Pa	Federal Street & Pleasant Valley R. R	8½	25	Sprague.
Pittsburgh, Pa	Pittsburgh Suburban Rapid Transit Co		3	Daft.
Pittsburgh, Pa	Squirrel Hill R. R	3½	5	Sprague.
Pittsburgh, Pa	Second Ave. Pass. Ry. Co	10	10	Thomson-Houston.
Plattsmouth, Neb	Plattsmouth Electric R. R	2	2	Sprague.
Port Chester, N. Y	P. C. & Rye B'ch St.Ry.Co.	3	5	Daft.
Portland, Oregon	Metropolitan R. R	3	4	Sprague.
Portland, Ore	Willamette Bridge Co	1.5	5	Sprague.
Quincy, Mass	Quincy St. Ry	5	4	Thomson Houston.
Red Bank, N. J	Red Bank & Seabright Ry.	5	3	Thomson-Houston.
Richmond, Ind.	Richmond St. Ry. Co	4	6	Thomson-Houston.
Richmond, Va.	Richmond City Ry. Co	7.5	50	Sprague.
St. Joseph, Mo	People's R. R. Co	10	20	Sprague.
St. Louis, Mo.	St. Louis Bridge Co	2	4	Thomson-Houston.
Salem, Mass	Naumkeag St. Ry	3	6	Thomson-Houston.
Sarat'ga Springs, N.Y.	Saratoga Electric Ry. Co	2	4	Thomson-Houston.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Electric Ry	6.75	6	Sprague.
Scranton, Pa	Hillside Coal Co	1	1	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Spokane Falls, W. T.	Ross Park St. Ry. Co	7.50	6	Thomson-Houston.
Springfield, Mo				Fisher.
Sterling, Ill	Union Electric R. R	6	7	Sprague.
Sunbury, Pa.	Sunbury & N'th'land Ry.Co.	3½	3	Daft.
Tacoma, Wash. Ter	Pacific Ave. St. R. R.	6	6	Sprague.
Tacoma, Wash. Ter	Tacoma Ave. St. Ry. Co	2	4	Sprague.
Toledo, O	Toledo Electric Ry. Co	2	2	Thomson-Houston.
Troy, N. Y	Troy & Lansingburg Street R. R.	5	6	Sprague.
Vancouver Island	Victoria Electric St. Ry.Co.	4	4	Thomson-Houston.
Washington, D. C	Georget'wn, Tenalley Town St. Ry. Co	6	3	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & West Side R. R.	4	3	Sprague.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.
West Bay City, Mich.	West Bay City Elec. Ry. Co.	5	8	Sprague.

Total—Roads 80

Notes.

THE SPRAGUE COMPANY has begun business in Europe. They recently closed a contract to equip a street railroad in Florence, Italy. The equipment provided for consists of seven miles of track and 10 motor cars.

THE 10 days within which the mayor of Troy, N. Y., could veto the electric railway franchise having expired, the franchise is now formally in the possession of the Troy and Lansingburgh Railway Co. The work of erecting poles and stringing the wires along the line of the road will now be prosecuted with the utmost despatch. It will not be long before the electric cars will be running from the iron works to Waterford.

THE SPRAGUE ROAD (Atlantic City).—It is reported that the electric cars at Atlantic City, N. J., have been much crowded recently, and that the electric railway is growing in popularity every day, on account of speed which the cars attain and the reliability of the service which they give. The cars now in operation each make 18 complete trips daily over the entire road, or nearly 120 miles per day per car. This, considering the fact that each car draws a tow car, and that both motor car and the tow car are often overcrowded is a record. The cars are in constant service, the operating company, the Pennsylvania Railway Co., keeping no reserve cars, so great is their confidence in the reliability of the apparatus. The Pennsylvania company have ordered an additional number of cars.

THE JULIEN ELECTRIC TRACTION CO. make the following statement:—

The Julien electric cars have now been in regular passenger service for a little over two years in Brussels; and a report has just been prepared of the cost of motive power during that time. The motive power includes the renewal of batteries, the wear and tear on motors and machinery, the generating and storing of the energy and repairs and replacements generally—in fact, every element that can be understood by an engineer to be motive power.

It has been found that the cost of motive power has been a trifle less than three cents per kilometer, or about five cents per car mile; in this, the cost of maintaining the batteries has amounted to 1¾ cents per car mile.

It may be of interest to know that the estimate of the cost of motive power as based on the experiences of the Julien Electric Traction Co. on the 4th and Madison avenues, and prepared prior to the report at Brussels and without any knowledge of the cost there, is within a fraction of being the same. The Julien company find the cost of motive power on Madison avenue to be 5.3 cents per car mile. In the cost of motive power as estimated in New York, however, was included interest on investment, amounting to 1.8 cents, leaving 3.5 cents per mile net, including depreciation on battery, cost of generating current and handling of batteries, as compared with the Brussels figures above.

INVENTORS' RECORD.

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From July 23, to August 13, 1889 (inclusive).

Alarms and Signals:—*Station and Want Printer*, M. D. Porter, 407,416. *Electric Signal*, G. McIntosh, 407,490, July 23. *Electrical Indicator*, E. R. Knowles, 408,018. *Electric Signal-Box*, D. A. Palmer, 408,042, July 30. *Electric Signaling Apparatus*, W. Eddy, 408,224. *Electric Call-Bell*, T. J. Smith, 408,676, August 6. *Fire-Alarm Box*, J. Speicher, 408,762. *Automatic Signaling Device for Time Service*, C. H. Pond, 408,846. *Electro-Mechanical Bell-Striking Machine*, T. F. Gaynor, 408,968. *Alarm*, J. M. Schmidt, 408,992. G. M. Williams, 409,088, August 13.

Clocks:—*Electric Clock for Use in Exposed Places*, A. Speer, 407,945, July 30.

Conductors, Insulators and Conduits:—*Underground Electric Conduit*, E. H. Phipps, 407,447, July 23. *Insulating Composition*, F. Marquand, 407,896 and 407,938, July 30. *Device for Suspending Electric Conductors*, T. E. Adams, 408,334. *Line Wire Insulator*, C. G. Graham, 408,383. *Method of Introducing Molten Insulating Material into Underground Conduits*, D. Brooks, Jr., 408,574. *Insulating Coupling for Pipes*, E. E. Erickson, 408,600, August 6. *Insulation for Electric Conductors*, C. T. Snedekor, 408,901, August 13.

Distribution:—*Multiple Wires System of Electrical Distribution*, J. A. Lighthipe, 407,485. *Core for Converters*, M. M. M. Slattery, 407,618, July 23. *System of Electrical Distribution*, F. L. Perry, 408,513, August 6.

Dynamos and Motors:—*Electric Generator*, C. E. Buell, 407,327, July 23. *Alternating Current Electric Motor*, E. Thomson, 407,844. *Alternating Current Dynamo*, G. Pfannkuche, 407,875, July 30. *Regulator for Dynamo-Electric Machines*, H. R. Boissier, 408,205. *Dynamo-Electric Machine*, same, 408,206. *Commutator for Electric Machines*, S. H. Short, 408,265. *Governor for Electric Motors*, G. H. Whittingham, 408,333. *Dynamo-Electric Machine*, S. Z. De Ferranti, 408,403 and 408,404. *Electric Motor*, S. C. C. Currie, 408,590. *Alternating Current Motor*, C. J. Van Depoele, 408,641. *Inductional Electric Motor*, same, 408,642, August 6. *Dynamo-Electric Machines*, J. T. Van Gestel, 408,768. *Electro-Dynamic Machine*, G. F. Card, 408,910, August 13.

Galvanic Batteries:—*Galvanic Battery*, W. P. Kookogey, 407,781; C. J. Hirlimann, 407,931, July 30. *Zinc Electrode for Galvanic Batteries*, J. R. Williams, 408,279. *Method of Producing Battery Solutions*, W. P. Kookogey, 408,629, August 6.

Ignition:—*Electric Gas Lighter*, T. J. Zoeller, 408,785, August 13.

Lamps and Appurtenances:—*Electric Lighting System*, F. E. Kinsman, 407,895, *Focusing Arc Lamp*, J. J. Wood, 407,915. *Electric Lamp Support*, A. T. Thompson, 407,973, July 30. *Manufacture of Incandescent Lamp Filaments*, T. D. Bottome, 408,236. *Carbon for Electric Lighting*, C. A. J. H. Schroeder, 408,358. *Shield and Reflector for Incandescent Electric Lamps*, G. Gibbs, 408,478, August 6. *Filament for Incandescent Electric Lamps*, A. F. Oppermann, 408,740. *Arc Lamp*, J. A. Lighthipe, 408,887. *Electric Arc Lamp*, W. H. Barker, 408,948, August 13.

Measurement:—*Electric Meter*, W. McKinney, 407,414; M. M. M. Slattery, 407,619, July 23; E. R. Knowles, 408,016 and 408,017. *Electric Measuring Instrument*, J. A. Barrett, 408,157, July 30. *Electric Meter*, S. Z. De Ferranti, 408,295, August 6.

Medical and Surgical:—*Electro-Galvanic Belt*, A. Dow, 407,473, July 23. *Electric Eye-Glasses*, H. Welcker, 408,151, July 30.

Metallurgical:—*Bath or Solution for Separating Metals from Their Ores*, J. C. Wiswell, 407,386, July 23.

Metal Working:—*Method of Electric Metal-Working*, M. W. Dewey, 408,875. *Electric Welding*, C. L. Coffin, 409,015, August 13.

Miscellaneous:—*Lightning Arrester*, J. W. See, 407,451. *Electric Cut-Out*, A. T. Smith, 407,455. *Electric Fixture*, J. C. Hollings, 407,593. *System of Protection from Lightning*, C. F. Hill, 407,660. *Galvanic Shoe*, J. S. Mellon, 407,673. *Water Closet Flushing-Valve*, J. W. Stevens, 407,746, July 23. *Calelectric Generator*, E. G. Acheson, 407,761, 407,762 and 407,763. *Electric Projector*, J. J. Wood, 407,914. *Stop-Motion for Dental Engines*, A. B. Cooke, 407,950. *Manufacture of Type Plates*, C. H. Perry, 407,962. *Non-Magnetic Alloy*, H. Ostermann & C. Lacroix, 408,130. *Method of Gelatinizing Electrolytes for Galvanic Batteries*, P. Schoop, 408,138. *Electric Switch*, H. T. Riggs, 408,194, July 30. *Electric Drill*, I. E. Storey, 408,269. *Gas Engine*, D. S. Regan, 408,356. *Method of Magnetically Reducing Friction*, M. W. Dewey, 408,465. *Magneto-Electric Individual Switching Apparatus*, J. W. Dunlap, Sr., 408,468. *Electric Lock*, L. Huebner & R. Busse 408,484. *Electric Drinking-Vessel*, F. W. Flint, 408,607. *Electrical Resistance*, F. O. Blackwell, 408,647. *Electric Switch*, W. Thompson, 408,678, August 6. *Electro-Magnetic Mooring*, H. P. Wellman, 408,778. *Electric Stop-Motion for Drawing Frames*, V. I. Cumnock, 408,839. *Machine for Removing Water-Hairs from Pelts, &c.*, A. Hedbavny, 408,879. *Phonogram Cylinder*, W. B. Tattershall, 408,938. *Insulating Nippers and Cutting Instrument*, F. M. Casey, 409,097. *Electrical Resistance*, E. M. Bentley, 409,135, August 13.

Railways and Appliances:—*Circuit for Electric Railways*, H. H. Cutler, 407,470. *Electrical Railway*, S. H. Short, 407,496 and 407,745. *Extensible Upward-Pressure Contact-Arm*, C. J. Van Depoele, 407,749, July 23. *Means for Propelling Vehicles by Secondary Batteries*, W. W. Griscom, 408,231 and 408,232. *Vehicle-Motor*, same, 408,233. *Electric Railway System*, F. J. Sprague, 408,544. *Contact-Arm for Electric Railway Motor-Cars*, C. J. Van Depoele, 408,638. *Underground Conduit for Electric Railways*, same, 408,639. *Multiple Motor Electric Locomotive*, same, 408,640. *Railway-Signal*, J. W. Riggs, 408,671, August 6. *Electric Motor for Street Cars*, W. S. Salisbury, 408,753. *Motor for Street Cars*, same, 408,754. *Electric Railway*, W. M. Schlesinger, 408,855. *Contact-Carrier for Electric Railways*, J. C. Love, 408,984. *Conduit Electric Railway*, B. Jennings, 409,104. *Motor for Street Cars*, W. H. Patton, 409,116. *Electric Railroad-Signal*, W. F. Grassler, 409,146. *Double Suspended Conductor System for Electric Railways*, C. J. Van Depoele, 409,156, August 13.

Secondary Batteries:—*Charging System for Secondary Batteries*, A. L. Riker, 407,683, July 23. *Secondary Battery*, V. H. Ernst, 408,002. *Means for Measuring and Regulating the Charge and Discharge of Secondary Batteries*. W. P. Kookogey, 408,112. *Alloy for Secondary Battery Plates*, E. R. Knowles, 408,182, July 30. *Secondary Battery*, T. D. Bottome, 408,287. *Secondary Battery*, N. B. Aldrich, 408,367; J. F. McLaughlin, 408,666, August 6. *Electrode for Secondary Batteries*, A. V. Meserole, 408,809. *Apparatus for Filling Secondary Battery Plates*, H. G. Morris & P. G. Salom, 408,986. *Electrode for Secondary Batteries*, W. P. Kookogey, 409,106, August 13.

Telegraphs:—*Automatic Telegraph*, F. Anderson, 407,406. *Automatic Telegraphy*, F. Anderson, 407,461. *Automatic Telegraphic Recorder*, same, 407,462. *Relay for Quadruplex Telegraphs*, C. L. Healy, 407,480. *Selecting Telegraph*, M. W. Dewey, 407,581. *Autographic Telegraph*, J. H. Robertson, 407,692. *Printing Telegraph*, C. L. Healy, 407,729 and 407,730, July 23. *Harmonic Telegraphy*, F. Van Rysselberger, 409,157, August 13.

Telephones and Appliances:—*Telephone*, J. Trowbridge and S. Sheldon, 407,799, July 30. *Telephone System*, J. R. Smith, 408,387, August 6. *Coin-controlled Apparatus for Telephones*, W. Gray, 408,709. *Method of Recording and Reproducing Sounds*, G. Bettini, 409,003. *Apparatus for the Record and Reproduction of Sounds*, same, 409,004, and 409,005, August 13.

EXPIRING PATENTS.

Patents relating to Electricity which becomes Public Property in September, 1889.

Recorder, J. M. Bachelder, 130,971; *Telegraph Pole*, A. B. Sprout, 131,037; *Rheostats*, G. Little, 131,171; *Key*, A. B. Shearer, 131,306; *Circuit Closer*, T. A. Edison, 131,334; *Printing Telegraph*, T. A. Edison, 131,335, 131,336, 131,337, 131,338, 131,339, 131,340, 131,341, 131,342, 131,343, 131,344; *Motor*, A. Schreiber, 131,377.

THE

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EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers*

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NOTICE OF REMOVAL.

The offices of THE ELECTRICAL ENGINEER *will be* REMOVED *during the present month* TO 150 BROADWAY. *After the first of November, all communications should be sent to the new address.*

THE COPPER DUTY—A CASE IN POINT.

THE recent fall of the price of copper in the American market should not abate the interest of the electrical trades in seeking from Congress the abolition of the duty on that metal. Nothing short of that consummation will serve to secure an equitable and stable relation between the price of copper to American consumers, the production of the metal and the rates in foreign markets. The duty is an absurd anachronism, to say the least, valueless to the national treasury and to everybody else except the copper mine owners, to whom, so long as it lasts, it is a constant temptation to greed and an ally in attempts to maintain high prices through combination.

A letter recently received from a valued correspondent in Europe furnishes a striking illustration of the influence upon international trade of taxing raw materials through the tariff. Our correspondent started a European branch of an American manufacturing company in 1882. Finding a good trade in insulated copper wire—of the kinds known as "office" and "annunciator" wires here—and observing that the price of copper in the United States was several cents a pound higher than in Europe, he concluded that his trade in the American made covered wire could not be permanent. The Europeans, he reasoned, would soon imitate the wire, and run him out, having their copper cheaper.

Machinery was therefore ordered from America for making that sort of insulated wire. About the time of its arrival, however, the price of copper in the United States had fallen to the European rate, the production from the mines farther west having knocked out the Lake Superior combination. The branch house, therefore, continued importing the wire from the United States and returned the machinery. One reason for not setting it up, says our correspondent, "was the fact that we should have had to import our copper wire from another country, paying a duty of a cent a pound, thus placing us at a disadvantage as compared with makers in England and Germany. The American wire we handled in bond, so that we paid duty only on the small quantity used in the country where we had established our business, and which furnished only about five per cent. of our foreign trade."

When the French copper speculation went to pieces, the American price was held stiffly at the old artificial rate for months after it had gone down to 9 or 10 cents per pound in Europe, the excess extorted by the copper ring from American manufacturers, over the European price, being four to five cents per pound—about 50 per cent. Under these conditions, it was of course impossible for the American house in Europe to import American insulated wire for sale in competition with European makers, now become numerous enough.

"Having occasion this year to establish a second European factory, in another country," says our informant, "we brought over machinery for making that wire, and have stopped getting it from America." Continuing, he says :—"It may be worth noting that the manufacture was lost to the country in which we established our first factory through the apparently trifling duty of a cent a pound on copper wire—ingot copper being of course everywhere free, outside of the United States."

A difference in the price of copper, between the United States and Europe of 20 per cent. is enough to swallow up all the profit in the export of many electrical supplies, such as insulated wire and cables, while it places American makers of dynamos, and of any other apparatus containing copper or brass, at a decided disadvantage in the markets of the world.

The recent drop in the American price improves the situation of manufacturers in the United States—but let us not complacently assume that the copper miners have experienced religion.

SOME ELECTRIC RAILWAY FIGURES.

A LINGERING doubt still appears to exist in the minds of the more conservatively inclined managers of street railways, especially in many of our larger cities, as to whether or not it is advisable or profitable to operate their cars by electricity. We are occasionally told that the whole business is an experiment, and not in every respect a successful one, and that while it may perhaps do very well in small towns where but few cars are run, it never will answer at all for heavy traffic. A glance at some of the information given to the stockholders of the West End Company, of Boston, by that energetic, wide-awake

and progressive manager of street railways and other large enterprises, Henry M. Whitney, of Boston, which we print in another column, may serve to encourage them. Mr. Whitney states that the cost of horse motive power in Boston, is 10.16 cents per car mile, which agrees very well with New York experience and cannot in any event be far out of the way. Experience has demonstrated that the maximum cost of electric power on the West End lines has thus far been only five cents per car mile, and even this low figure the engineers promise shall be largely reduced as the plant is increased. Now, according to the Massachusetts railroad commissioners' report of 1889, the West End company's cars ran 13,495,511 miles during the preceding year, from which it is not difficult to figure out a saving on the present business of some $674,775 per annum. Mr. Whitney brings forward some other facts of a comforting nature for future street railroad proprietors, one of which is that the gross receipts of one of his lines were doubled, and those of another increased 150 per cent. by the introduction of electricity in place of horse-power. We learn, moreover, that the average rate of speed on the Cambridge surface line is 12 miles per hour as against 10.89 miles per hour on the alleged rapid-transit-elevated-steam-railroads of the Manhattan company in New York. The net income of the West End company, according to the report above quoted, is approximately 5.8 cents per car mile. Hence it appears that the result of changing from horses to electricity will ultimately result in doubling the net income of the company on the present business, to say nothing of the enormous increase which rapid communication and improved facilities are sure to engender as soon as they are provided. There is much food for thought in these figures.

The National Telephone Association is hardly more successful than the United States Senate in keeping its proceedings in "executive session" from the public. Another attempt was made at Minneapolis, with the usual farcical result that nobody who cared to find out what was going forward had any difficulty in doing so, and the weekly electrical journals promptly printed abstracts of the proceedings with nearly all the papers read before the convention. The point of secrecy came up in connection with the paper of Messrs. A. S. Hibbard, J. J. Carty and F. A. Pickernell, on "A New Era in Telephony." A majority thought that paper should not be made public, and solemnly resolved—13 to 11—that, after reading, it "should remain in the secretary's possession and should not be published." It was, however, printed in the *Western Electrician*, issuing before some of the delegates had reached their homes.

It is difficult to conceive why it should have been thought expedient to suppress the paper on "A New Era in Telephony." A microscope would disclose no traces in it of dynamite or other explosive dangerous to the solid fabric of commercial greatness erected by the American Bell Telephone Co. and its lessees. It contained nothing more inimical to the vested interests in telephone property than can be discerned in an elaborate and painstaking account of the "metallic circuit" system of telephone working, now employed upon long-distance lines and in some large city exchanges, setting forth fully both the advantages of that method, in the improved service obtained, and the increased cost of line construction and apparatus.

The presentation to the convention of the resolution adopted by the National Electric Light Association, at Niagara Falls, authorizing the appointment of a committee to petition Congress for the abolition of the customs duty on copper, and an attempt to obtain similar action by the telephone association, aroused instant and vehement opposition from Mr. Wallace, of Montana, and from Mr. Metzger, of Pittsburgh. Neither of them urged anything against the merits of the proposition. The former said he was afraid he would lose his telephone subscribers in the copper mining territory of Montana, and Mr. Metzger was aghast at the bare thought of seeming to antagonize the sentiment of the community and state which he considered himself to represent. It is claimed by some who were present, that if the resolution had been put to vote it would have been adopted by a majority of four-fifths; but the promoters of the measure withdrew it out of deference to the gentlemen who opposed it. The late General Hancock was not so very far out of the way, after all, when he said "the tariff is a local issue."

We regret to hear of the reported ill-success of the electric system on the Richmond (Va.) Union Passenger Railway; but by those acquainted with the facts in the case, the alleged troubles recounted ought not in fairness to be used as an argument against electric traction in general. The Richmond system was the first large electric railway contract ever undertaken by the Sprague company, or indeed by anybody, and the work has of necessity been largely of an experimental character, and hence costly, patience-trying and more or less unsatisfactory to all concerned. Yet we venture the prediction that the abandonment of electric propulsion in Richmond, if it take place at all, will only be temporary, for the reason that under the difficult conditions existing in that city, it is a simple impossibility to furnish an equally cheap and reliable service in any other way. Practical electricians will readily understand the enormous disadvantages under which Mr. Sprague was compelled to work in organizing the Richmond plant, as a pioneer enterprise, and will be slow to believe that the responsibility of the failure—assuming that it actually is a failure—rests wholly or chiefly with him or with his company. It is too late in the day to take a retrograde step in this department of transportation service, except possibly a temporary one due to special and unusual reasons.

In the collection of somewhat remarkable letters exchanged between Harold P. Brown and his various correspondents, recently printed through the enterprise of one of the daily newspapers, perhaps none has excited more comment, or occasioned so much surprise, as the one addressed to a professor connected with Johns Hopkins University, of Baltimore, of which the following is part:—

My Dear Mr. Duncan—You have probably seen from the newspapers that I have gained my point against the Westinghouse company, by selling to the state of New York three of their dynamos for electrical executions. I have permission to use one of these dynamos (650 lighter) to send to you for an efficiency test with a load of converters and lamps, and these are promised to me within a week. * * * * As the W. people are very anxious to find out from whom I bought the apparatus and when the test is to come off, if at all, I shall take all possible precautions to keep it from them. I do not care to expose others to the effects of their ill will, nor do I wish their agents prying about during the tests. * * * * I am sorry that this matter has hung fire for so long, but you can appreciate the amount of work necessary to get hold of the apparatus and the necessary funds to carry the matter through.

The inquiry naturally suggests itself as to why one of the faculty of an institution of the character and standing of Johns Hopkins University, should be expected to feel an interest in the fact that three Westinghouse dynamos had been sold to the state of New York for electrical executions, in order to make "a point against the Westinghouse company." We do not believe that Dr. Duncan felt any such interest, but should have supposed that some explanation of the matter would have been forthcoming before this time.

It is much to be regretted that some of our electrical contemporaries have been unable to express their disapproval of the course of President Weeks, Mr. Morrison, and others, at the recent electric light convention, without descending to the use of abusive and blackguard language and personal imputations, such as might be looked for in a row among grog-shop politicians. The worst of that sort of thing—to say nothing of its indecency—is that it has a boomerang quality and may be more dangerous to assailants than to the assailed; defeating the purpose of the criticism by enlisting a feeling in favor of people subjected to wholesale and virulent revilings. That any fair minded members of the National Electric Light Association really think Mr. Weeks or Mr. Morrison indifferent to the best interests of that body, we do not for a moment believe, however greatly they may deplore what seems to them the injustice of the action of those gentlemen at Niagara Falls. The superserviceable organs of discontent may do much harm to the association by continuing their intemperate course. The organization has become important and useful. It can be, and is likely to be, made vastly more useful to the rapidly growing numbers of men engaged in the supply of electric light and power. The increase of membership during the past year, the successful establishment of a permanent secretaryship and headquarters—keeping up the continuity of the association's work throughout the year—the manifest desire at the last convention, exhibited in papers and discussions, to direct the work towards the accumulation of practical and statistical information of immediate value to the members in their business, all are indications of the success—in the line originally intended—that can be attained by concerted action.

For about a year there have been signs, not a few, that some personal quarrel, grudge, offence, or what not—the exact nature of which has not come to light—has lain behind contentions on the floor of the convention. The bones of some mysterious and unseen bogey have been heard to rattle in an ominous way several times, apparently scaring the timid. If any member has brought a skeleton in his pocket to recent conventions, it would be better next time, either to leave it at home, or to trot it out on the floor and let all have a good look at it. If it prove but a chimera it will be laughed out of sight; if it be anything more formidable, there are enough able-bodied men in the association to lay it low.

The New York *Times* of September 1, devotes a column to pending and impending telephone litigation, presenting a curious mixture of facts and fancies touching the pending government suit, the microphone interferences in the Patent Office and a prospective legal fight between the Bell company and the Western Union Telegraph Co. The *Times*, or its informant, thinks "Daniel Drawbaugh is naturally the primal figure in each issue," and says that the present Drawbaugh trustees "are in the fight to stay, backed by the government." This has an old-time ring.

The announcement, well or ill founded, that the Western Union company will shortly bring suit against the Bell company to determine the terms of the contract between them, is far the most important feature of the *Times's* article. Disagreements concerning the divisions of gains under the settlement which terminated the telephone war between these companies 10 years ago, have been reported at various times since, while the extensive and successful introduction of the long-distance telephone service by the Bell company between important centres, alleged to have seriously lessened the telegraph service between such points, apparently constitutes a further grievance, Attentive observers have noted from time to time the signs of approaching hostilities between the Bell and Western Union companies, and will watch the fight with keen interest when they lock horns in earnest.

OBSERVATIONS.

BY THOS. D. LOCKWOOD.

Some time ago I said in this column, something about aluminium. Since then I have found out from the Chicago *Herald* how to make it. This exponent of electrical science says, "Aluminium is being separated from the oxide by means of an electrical current. The oxide is dissolved by some metallic *flouride* and *the pure metal is deposited in a fused form.* The substance employed as a solvent can be used for an indefinite time, as none of it is wasted or decomposed by the electrical action." This is all. We are not informed what use is made of the fused aluminium, but it may be supposed that it is subsequently cast into any required form for use.

. . .

It is not new to contemplate or to suggest the use of electricity as an agent of punishment for criminals. The third form of magneto-electrical machine was that made by Mr. E. M. Clarke, "Magnetician," London. One of its recommendations as recited in Sturgeon's Annals of Electricity for 1837, is its capability of being used as a substitute for the "cat." The descriptive writer after enlarging upon the strength of the shock given by this machine, goes on to say: "Indeed the effects are so violent, that the inventor has proposed to many of his military customers that this instrument would be a good substitute for the lash, being capable of producing even greater torture than that brutal instrument, without producing any corporeal injury to the delinquent."

. . .

The induction coils used in the operation of the first Atlantic cable of 1858, consisted of a cylindrical core of iron wire, round which were wound first, a fine and long wire constituting a secondary coil; and second, a coarse and short wire forming the primary coil; the winding thus was the reverse of the usual Rhumkorff winding. The primary wire upon each pair of coils consisted of 48 No. 14 gauge wires, arranged in parallel circuits, as one large conductor. These coils were made and operated by W. Whitehouse, and probably hastened the inevitable fate of the cable.

. . .

We are now hearing a good deal about the "telephote," "telectroscope," etc.; an instrument whereby we are to be enabled to see electrically what is going on at a distance as well as we can now hear by means of the telephone. And we have been treated to affecting stories, which movingly recite that Edison is going to do this; while a certain French savant says that he already has done it,—almost; and that an interview has been arranged, where each is to spread before the other a true account of what he has done, so that there shall be a fair division of labor, and glory.

But much of this seems indeed to have "a very ancient and fishlike smell." Way back in 1881, as I recollect it, a certain philosopher announced to the press and the world, that he had deposited a sealed paper in the Smithsonian Institution, the contents of which should only be made known at the forthcoming meeting of the American Association for the Advancement of Science. The said philosopher had a great name, and somehow or other, many rival inventors jumped to the conclusion that he had evolved a plan for "Seeing by Electricity" which he was about to spring upon an unsuspecting world; and it was remarkable what a number of persons rushed into print before they knew the contents of the sealed paper, to advance their own claims to the prior inventorship of plans for electrical seeing. But the fall meeting of the A. A. for the A. of S. came along, and the sealed packet philosopher opened his seal; whereupon it was found that he had not touched the subject of electrical seeing, at all, but had stuck to his own last, and had only worked out an improvement in the electrical transmission of speech, which consisted in dispensing with the wire, and in the use in lieu thereof of a sunbeam. The would-be anticipators were never heard of again But, to parody Patrick Henry:—I care not what others may do, so long as they do not invent a plan for "smelling by electricity."

ARTICLES.

ALTERNATING CURRENT MOTORS: THE EVOLUTION OF A NEW TYPE.[1]

BY LIEUTENANT F. JARVIS PATTEN.

On giving our secretary the title of this paper it was my purpose to treat the subject in a broader light, and to show the progressive steps in a series of experiments which led eventually to the type of machine that I shall bring to your notice this evening. The recent and urgent claims of other work have rendered such a treatment impossible at the present, and I shall limit the paper to a description of a new alternating currrent motor, one form of which is shown in the accompanying drawings.

The place that the alternating current electric motor is destined to fill in the industrial arts is familiar to you all, and the various ways known to the scientific world by which such machines may be rendered operative have been ably considered and elaborately discussed in the Institute papers of the past two years by Professor Thomson, Dr. Duncan and Mr. Tesla. We are thus all more or less acquainted with the prominent difficulties of the problem.

My experience, in common with that of my predecessors, teaches that the alternating current motor has a strong and persistent disposition to stand still, and when persuaded to motion it is apt to be a sort of "go as you please" machine, and asserts its inherent right to turn in either direction indifferently; direction of rotation in some cases being purely a matter of chance. I shall not have much to say about efficiency, as my experiments with large machines are not sufficiently advanced to furnish any reliable data, but I will endeavor to give a general solution of the problem designed to meet the following conditions of practice.

1st. A machine that will start itself independently of the speed of the generator or number of alternations of current per unit of time.

2d. A machine that has but one direction of rotation and cannot reverse under any conditions of current alternation.

3d. A machine that is not necessarily synchronous with the generator, revolution for revolution.

4th. A machine in which reversals of current direction do not produce corresponding reversals of magnetism in any iron part, when the machine is in motion at its normal speed and maximum efficiency.

5th. A machine of simple form having an ordinary continuous wound armature revolving in a single or two pole field.

Referring now to the figures, which are simply diagrams of the circuits and operative parts, we have in figure 1 an ordinary closed circuit armature, shown as a Gramme ring merely for convenience of illustration, the points of the winding intermediate between the eight coils being connected in the usual way to the eight segments or bars of an ordinary Gramme collector, and it may be well in passing to note here the functions of this collector. It is not a commutator in the strict sense of that term, as it does not rectify or redirect reverse or opposed currents. If the brushes b^1 and b^2 were held upon the outside wire of the ring the same results would follow, and the Gramme collector properly so called, simply transfers the brush contact from point to point of the continuous ring winding. If a source of direct current be interposed between the terminals A^1 and A^2, current will flow continuously from brush b^1 to b^2 downward through the right and left hand halves of the ring in the direction of the arrows k^1 and k^2, making say a south pole in the ring at the upper point s, and a north pole at the lower point *n*. With a continuous current these poles would be continuously maintained and placed in the magnetic field indicated by N and S, the armature would continuously revolve in the direction indicated by the arrows, E, E. If now a source of alternating current be inserted between the terminals A^1 and A^2 the polarities of the ring would be reversed at each successive alternation of current, and if a direct impulse indicated by the single arrows in the external circuit produced the poles *n* and *s* in the ring, the reverse impulse indicated by the double arrows would produce the opposite polarities n^1 and s^1 at the same points, and the tendency to motion would be reversed if the fields remained the same; but it will be noted the motion would be in the same direction still if the fields were also reversed by the same reversal of current. If, however, the field were maintained constant as indicated by the large letters N and S, and some device could be contrived by which at each reversal of the alternating current, the brushes b^1 and b^2 could be made to change position, either mechanically or otherwise, then with an alternating current a constant polarity *s* and *n* would be maintained at the upper and lower points of the ring—for then a direct impulse starting from A^2 to the right would enter the ring through the brush b^1 flowing down both sides in the direction of the arrows k^1 k^2, out through brush b^2 and back to the same source at A^1. The reverse impulse indicated by the double arrows would start from A^1 to the left, going to brush b^2 and if we now suppose this to have changed places with the brush b^1, the reverse current would then enter the

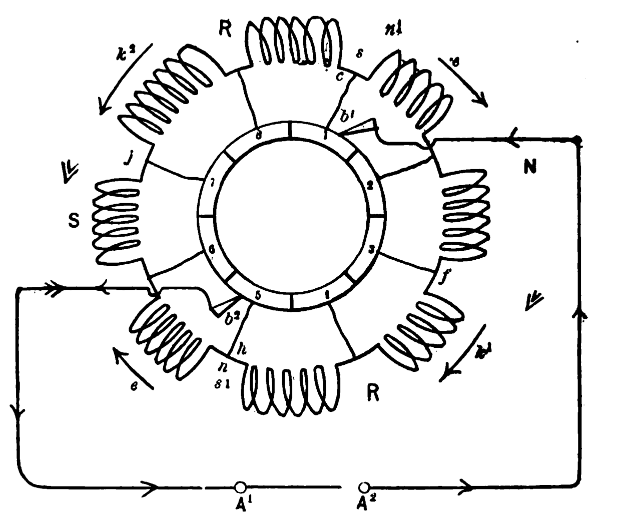


Fig. 1.

ring at s, and flowing down both sides in the direction of the arrows k^1 and k^2 would leave through *n* and the brush b^1 and so back to the source A^2, maintaining the polarity of the ring the same as before. If the brushes could be thus changed at each alternation, the polarity of the ring would be maintained constant with an alternating current. While however it is quite impractical to thus cause the brushes to change position mechanically at each reversal of current it is perfectly feasible to produce the same effect without the mechanical change. The means of accomplishing this result are indicated in figure 2, which is identical with figuure 1, with a single exception. There are eight coils as before and eight bars in the collector, the odd numbered bars 1, 3, 5 and 7, are connected to the same points of the ring as before *c*, *f*, *h* and *j*, but the even numbered bars, 2, 4, 6, 8, are connected respectively to points of the ring diametrically opposite them, bar 2 to the point *d*, bar 4 to the point *g*, and so on each even numbered bar to a correspondingly opposite point of the winding. If now a source of alternating current be interposed between the terminals A^1 and A^2 and we make the supposition that the ring shall turn through an arc of the circumference equal to that covered by one bar of the collector during each alternation of current we shall still maintain a constant polarity at the upper and lower points of the ring without causing the brushes to change position mechanically.

Thus a positive impulse starting from A^1 to the left, and

1. Paper read before the American Institute of Electrical Engineers, New York, September 10, 1889.

indicated by single arrows enters the ring at b^1 flows down both sides to n, producing the ring polarities s and n, out brush b^2 and back to source at A². The reverse impulse being in the opposite direction will start from A² to the right, go to brush b^2 which we will now suppose bearing on segment 4 of the collector whence it will go by the inverse connection to the opposite point s^1 of the ring then down both sides in the same direction as before to the point n^1, thence back to the opposite segment 8, out brush b^1, now bearing on this segment and back to source at A¹.

The reverse currents therefore under the assumed conditions are caused to maintain a constant polarity in the ring so that in a constant field its tendency to motion would always be in the same direction with an alternating current in the armature. It will be further noted that the alternating current is not redirected or commuted in the strict sense of the word and we may enunciate the fundamental principle which underlies the construction of this type of machine as follows :—

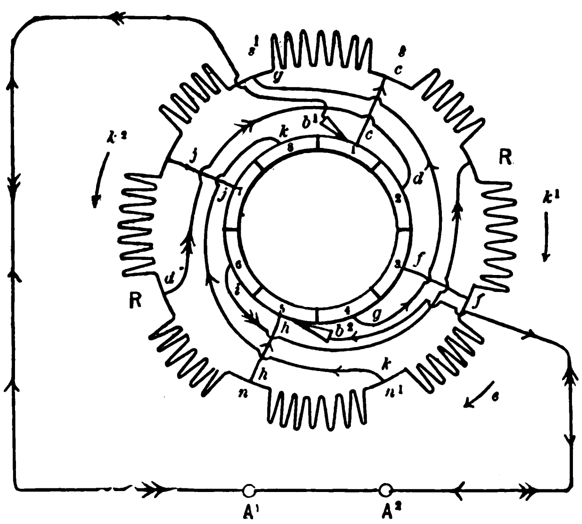


FIG. 2.

"*The poles of any closed circuit may be maintained constant with an alternating current by causing opposite impulses to traverse the circuit in opposite directions.*" The direct and inverse connections shown in figure 2, have precisely this effect, when, as supposed, a single bar of the collector passes under the brushes at each reversal of current. The connections *c c*, *d d*, *f f*, &c., in figure 2 may have any form, and other bars may be interposed between their extremities without affecting in any way their functions as connectors. This step is shown in figure 3, where another collector bar 1 *c*, 2 *d*, 3 *f*, &c., is inserted in each of the connections *c c*, *d d*, &c., of figure 3, thus making another collector shown outside the first to avoid confusion of the drawing, while for the same reason the source of alternating current A¹ A² is placed inside the inner ring. As the polarities s and n of the ring are maintained constant as previously described with an alternating current, and current is constant in direction from s downward through the right and left halves of the ring to n, so must necessarily any current be constant in direction which is led from brushes through any shunt circuit connected to the segments 1 *c*, and 5 *h* of the outer collector ; a field circuit of constant direction may therefore be shunted from this outside collector. This is shown in figure 4, in which 12 coils are shown in the ring and 12 bars in each collector connected alternately direct and inverse as before. Tracing now two opposite impulses of current we have the first indicated by the single arrows from source A¹ to segment 1 of the inner collector, thence to segment 1 of the outer collector, where the current divides, part going down the right and left hand halves of the ring to n, and part out brush b^3 through the field circuit making the poles N and S back to brush b^4, segment 7 of outer and segment 7 of inner collector to the terminal A² of source. If the armature be

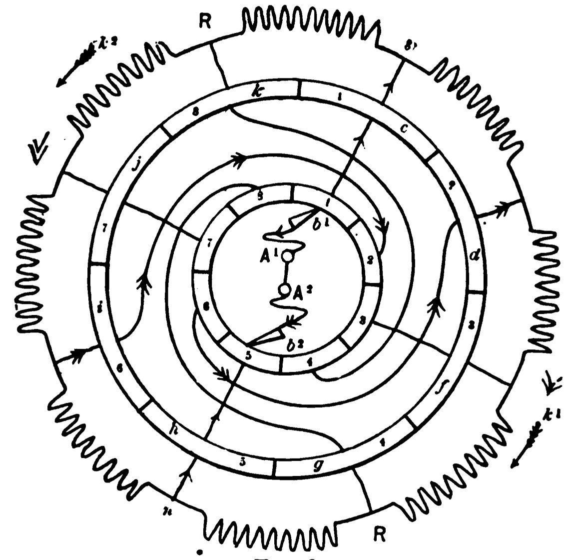


FIG. 3.

supposed now to turn through the space covered by one collector bar the reverse impulse can be traced as follows : Starting at A² in the opposite direction to brush b^2, now bearing on segment 8 of the inner collector, thence through the reverse connection to segment 2 of the outer collector, now under brush b^3 where the current divides, going part as before down the right and left halves of the ring making a south pole at s^1 and a north pole at n^1 as before and the other part out of brush b^3 through the field circuit in the same direction as before back to brush b^4, now on segment 8 of the outer ring thence through the reverse connection back to segment 2 of the inner ring, now in bearing with brush b^1 and so returning to the source at A¹. Thus the two impulses of opposite direction have been made to traverse both armature and field circuits in the same direction ; we have, therefore, with an alternating current constant arma-

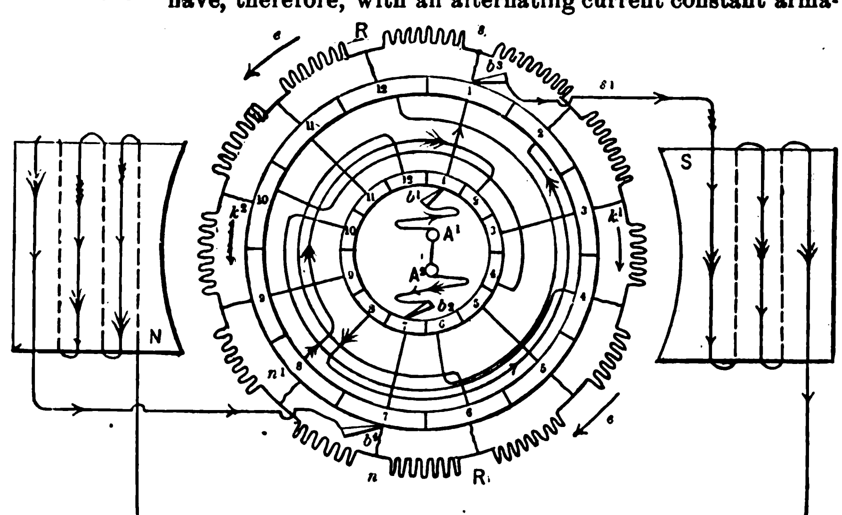


FIG. 4.

ture polarity and constant field polarity, and, therefore, a constant tendency to motion in the same direction. Not only this but the further condition is fulfilled that there are no reversals of magnetism in any iron part so long as one bar in the machine, as shown in figure 4, passes under the brushes at each alternation of current. It remains to show

how this is brought about. Referring again to figure 4, let it be supposed that the first impulse of current did not cause the armature to turn through the arc of the circumference subtended by one segment, but all the brushes still bore on the same segments as shown in the figure and the reversals of current continued—by tracing the circuits it will be seen that each reversal of current reverses the polarity of both field and armature and with either direction of current or rapid reversals, there will be a constant tendency to motion always exerted in the same direction. The machine under these conditions becomes therefore simply a direct current machine on an alternating current circuit with a constant tendency to start in one direction. Assuming the machine, therefore, self-starting, it will continually gain in speed until the condition is fulfilled of one segment passing the brushes at each alternation, for it then becomes in the broad sense a synchronous alternating motor. The current then produces no reversals of magnetism, and there is a true alternating current in the armature circuit producing, however, no reversal of armature polarity; and a current of constant direction in the field. Under these conditions the motor is self-regulating, moving at a constant speed and with a maximum rotary effort.

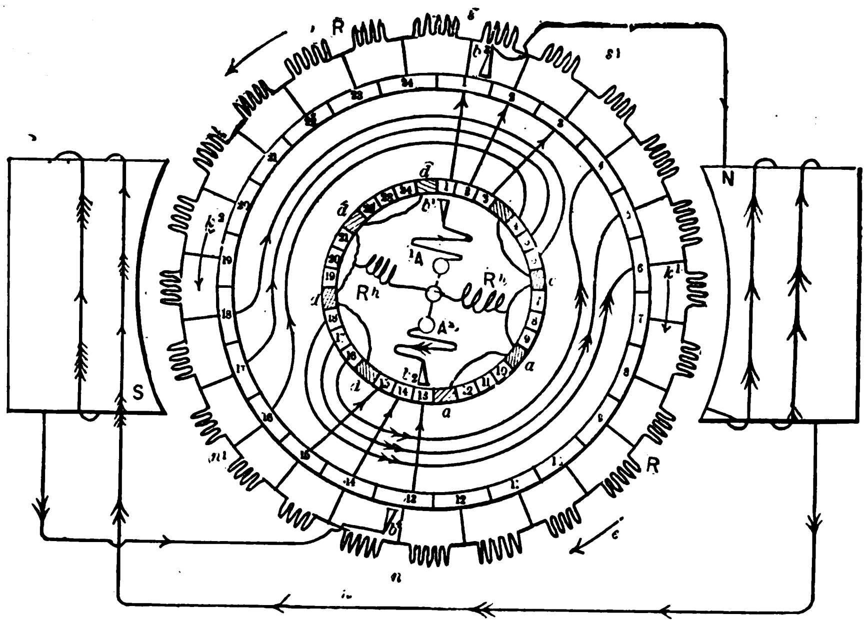


FIG. 5.

It is not however essential that one bar should pass the brush at each alternation, as any number may be caused to do this depending upon the speed required and the number of coils upon the armature. This is illustrated in figure 5, where the complete machine is shown. There are 24 coils in the armature, 24 bars in the outside collector, and 32 bars in the inside one, this latter being composed of 24 connecting and eight insulating bars. The connecting bars of the inner ring are numbered to correspond with those of the outer ring around to the right from 1 to 24;—the insulating bars drawn shaded, separated the others into groups of three. In this machine three segments 1, 2, 3, in the outer ring are connected direct to the corresponding segments 1, 2, 3 of the inner ring, likewise the opposite three, 13, 14, 15 of one ring are connected direct to 13, 14, 15 of the other. The next group of three is connected inversely, 4, 5, 6 of the outer ring to the diametrically opposite bars 16, 17 and 18 of the inner, and the corresponding opposite group, 16, 17, 18, of the outer ring are likewise connected inversely to the diametrically opposite group 4, 5 and 6, of the inner ring. The remaining segments are connected in the same manner, but the connections are omitted to avoid confusion of the drawing. The operation of the machine is evidently the same as that shown in figure 4, except that the required conditions are fulfilled in this instance when three bars of the collector pass under the ring at each alternation of current, and as there are 24 segments arranged in groups of three, the machine at its normal speed would make one revolution for every eight alternations of current and connected in a circuit supplied with 16,000 reversals per minute its normal speed would be $\frac{16,000}{8} = 2,000$ per minute, and with 48 segments arranged in groups of three its speed would be 1,000 per minute. The blank segments insulating the groups of the inner ring are connected to the extremities of a rheostat which is enclosed inside the commutator, and is designed to offer a path for the alternating current such as there may be, and prevent its absolute rupture at the period of change from one group of segments to the next; they also serve an important purpose in preventing a dangerous short circuit which would be occasioned by the inner brush bridging two groups of segments oppositely connected.

It follows as a matter of course that as the machine starts as a direct current motor connected in an alternating circuit, rapid reversals of magnetism will at first be produced in all the iron cores, and these should be made of laminated iron to prevent undue loss by heating at the period of starting. The machine in fact starts as a direct current motor and automatically changes to a sort of synchronously alternating motor. It gains its normal speed at this point, is self-regulating and its capacity of doing work is a maximum.

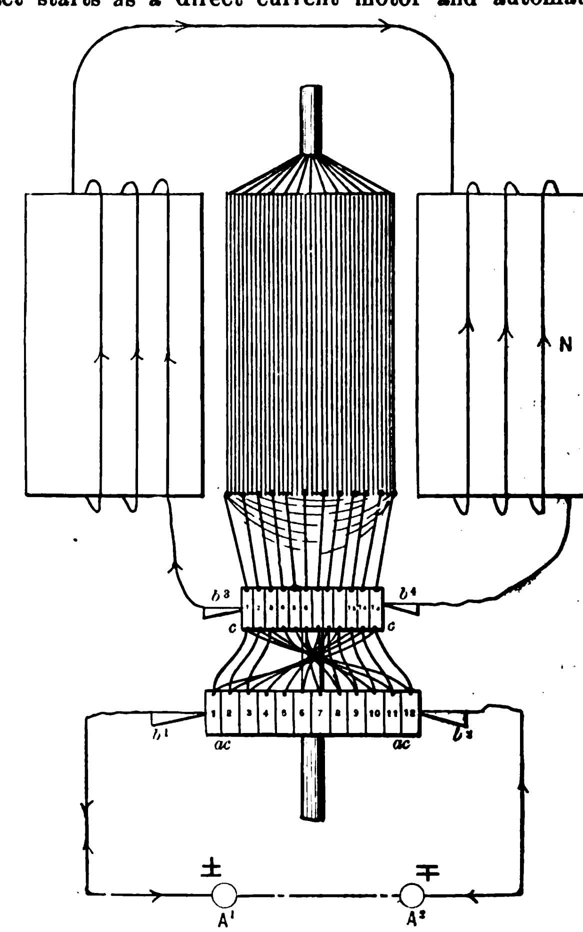


FIG. 6.

Figure 6 shows a plan of the machine as constructed—it

consists simply of an ordinary closed circuit armature in a single field; *c c* is the ordinary collector, really a part of the armature circuit from which the brushes b^3, b^4 take a current of constant direction to the field shunt; *a c*, *a c* is the reversely connected commutator and the brushes b^1 b^2 bearing upon this commutator are connected to the terminals of the alternating current circuit.

NOTES ON THE FRENCH EXHIBITION.

BY AN AMERICAN ELECTRICIAN.

In a general examination of the great Exhibition, the electrical engineer will find that although there are very many electrical exhibits, it is, taken all together, not a good representation of the state of the art. Although there are some very interesting exhibits and some very creditable ones, yet as a whole it is not what might have been expected, at least by an American; for there is no doubt that as far as electric lighting and transmission of power is concerned the United States is in the lead in many respects.

In general, the illumination of the grounds of the exhibition is by means of gas. The really grand and impressive Eiffel Tower, with the beautiful grand dome on the one side, and the magnificent Trocadéro with its terraces of basins on the other, are all lit up with millions of gas jets artistically placed in rows and groups, outlining the general contour of the structure. The effect is unquestionably magnificent; the slight flickering of the gas lights in the wind, which could not have been produced by incandescent lights, adds very much to the effect. Among the most imposing exhibits of electrical illumination are the large light-house lamp at the top of the tower, alternately red, white, and blue, which is visible for 50 or 60 miles; the three great projecting lights also on the tower, the huge beams of light from which, rendered visible by the moist atmosphere, produces a very striking effect; and last, but by no means least, the very attractive illuminated fountains with the large invisible arc lights underneath (requiring 300 h. p.) reflected through colored glasses up through the streams of water, and producing a really beautiful and artistic effect. Besides these, the interior of the buildings (only some portions of which are open in the evening), and some portions of the grounds, are lighted with electric lamps.

The illuminated fountains and the projectors on the tower are good and striking examples of illuminating effects which cannot be produced by gas, and the fact that almost all of the interiors of the buildings of the exposition, which are open at night, are lighted by electricity, shows that unquestionably the electric light is preferable in many respects, in this case probably on account of the smaller first cost of installation in temporary buildings, smaller fire risk, and the fact that it does not vitiate the air.

The gas companies here in Paris are able competitors, and still have the upper hand, as the whole electric lighting of Paris is probably less than on any one of the large well-lighted streets of New York. The chief reasons for this are probably because no overhead wires are allowed, and that underground wires are practically prohibited, because the authorities will not allow them in the sewers, and the digging up of the well paved Paris streets with their deep foundations is an expensive undertaking. All this will probably result in placing the wires under the sidewalks, which in fact has already been done in some cases. In the greater part of the exposition the wires are hidden, both in the grounds and the buildings.

The dynamos at the exposition show in some cases progress in design and construction, in others there appears to be an absence of the modern almost universally acknowledged improvements, while still others (in the opinion of many electricians) show steps in, apparently, entirely wrong directions. The efficiency of any well-built dynamo of the ordinary type and simple construction, is so high that a complication of construction to increase this efficiency is hardly warranted. Unless, therefore, any complications in construction result in a greater output per pound of the material, or in less cost of construction, or some other similar advantage, they can hardly be termed improvements. In several cases the complication of the parts is so great and the construction so poor, from a mechanical point of view, that the machines will undoubtedly die a natural death in competition with what might now be called the standard type of dynamos.

Among the foreign machines the one which seems to meet with most favor from electricians is the large four pole Oerlikon machine, in the Swiss exhibit, designed by Mr. Brown. The design is simple, massive and rigid. The armature is of the Gramme type with one layer very neatly wound. The four short field magnets radiate from the centre and are connected at their outer ends by one common yoke piece. Coils are wound with very broad copper bands. It is used for transmission of power and is a series machine, the motor being also series wound; the system is claimed to be self-regulating for constant speed when the load on the motor varies. It is for 250 h. p., and makes 600 revolutions. Another machine of the same firm has a Gramme armature, the iron core of which extends almost to the pole-pieces, and has round holes punched through it very near the outside surface; insulated copper bars pass through these holes, and are so connected with return strips through the interior of the ring as to constitute a Gramme winding. It is claimed that by this means the same intense field can be obtained as with teeth or lugs, while it has the advantage over the latter, that it does not induce the foucault currents in the pole-pieces.

One of the favorite general designs of all the standard continuous current dynamos seem to be an upright U-shaped magnet with one coil on each core, and a short cylinder or ring armature, usually the former. Among these are the Edison, the Thomson-Houston (new type), the smaller machines of the Société Alsacienne, the Rechniewski, and others. They differ in that some of them, like the Edison, have the armature at the bottom and others have it at the top. The former has the advantage of stability, and that the vertical upward magnetic pull on the armature is in opposite direction to the weight of the armature, while in those with the armature at the top the magnetic pull and the weight of the armature are both downward, thereby making the pressure on the bearing much greater.

The large Edison machine for 2,500 16 c. p. lamps giving 140 volts at 450 revolutions (weight 28,000 pounds), is of the well-known type used in the new Philadelphia central station. The large Thomson-Houston machine has the armature at the top, and has the series coils of the compound winding around the edges of the pole-pieces, by means of which arrangement it is claimed the same magnetic effect on the armature is produced with less wire, because the wire is more effective in that position. It is their standard 80 h. p. machine of 500 volts at 900 revolutions, for the transmission of power.

In the Rechniewski machine both the field and armature are made of laminated sheet iron. The field has no magnetic joints being all in one piece; the armature has very many lugs. The object is as follows:—The magnetic field cut by the armature wire can be made much greater if the latter has teeth or lugs, but as these lugs would produce bad foucault currents in the pole-pieces the field must also be laminated; furthermore, the magnetic density can be made much greater in such laminated fields, and therefore the core and coils smaller. The result of the combination is a machine with a very large output for its size and weight, and amount of copper. The cost of stamping these plates does not appear to be materially different from the cost of making a solid magnet having the same magnetic intensity.

The Derosier machine contains a number of horizontal pairs of magnets opposite to each other, as in the well-known older alternating machines. The armature consists of radial wires passing between these magnet poles and returning through opposite fields in such a way as to give a continuous current. The principle of the machine is practically the same as that of a machine constructed by Edison many years ago, and shown at the Philadelphia electrical exhibit in 1884. The advantage is that there is no iron in the armature, and as the diameter of the armature is necessarily very large a great conductor velocity can be obtained at a comparatively low number of revolutions, thus enabling the dynamo to be coupled directly to the engine, which appears to be a favorite method here. It will be seen that the amount of inactive (dead) wire on such an armature must be comparatively great and the construction quite difficult. Radial german-silver strips are used between the wires to assist in giving the mechanically weak part of the armature additional strength. The large machine exhibited here, gives 144,000 watts at 200 revolutions. It is a question whether the advantages claimed warrant the introduction of such a complication in the construction.

The other large machine is the so-called Belford type of the Société Alsacienne de Constructions Mechanique, which might be described as an ordinary multipolar Gramme machine "turned inside-out," that is, having the fixed radial magnets in the centre and the Gramme armature on the outside. Great inductor velocity is thereby obtained at a comparatively low number of revolutions, but the construction is very much complicated. The commutator of this machine is constituted of the outer wires of the Gramme ring on which as many pairs of brushes slide as there are poles inside. This very large commutator, about six feet in diameter, gives the machine a peculiar appearance. A complicated system of links, levers, and gear wheels, on the side of the machine enables all of the brushes to be moved simultaneously. It is coupled directly to the engine and generates 125,000 watts at only 150 revolutions, the surface velocity of the commutator being, therefore, between 40 and 50 feet per second.

Another novel dynamo is the Deprez, having two straight horizontal field magnets and two Gramme armatures on the same shaft, one between each of the two opposite poles of the two field magnets. The driving pulley is placed in the middle of the machine between the field magnets.

The new Thomson-Houston alternating current compound machine is of considerable interest to electricians as the whole of the armature current is "redressed" (that is, changed into a continuous current) in a portion of its circuit without the slightest signs of sparking at the commutator, even when the external load is varied very much. This redressed part of the circuit contains the series coil of the field magnets. The difference of potential of the redressed part is quite small, which partly explains the absence of sparking. A self-induction coil across the terminals of the redressed part also assists in diminishing the sparking.

There are numerous accumulators here, but none from the United States. Besides a few novelties in the supports and terminals of the plates, the general tendency of inventors, as exhibited here, is to provide means to retain the active material in the grids, and preventing the plates or the materials of the plates from touching each other. Dujardin does this by filling the space between the plates with a coarse granular silicate, which is artificially made and has the property of being very porous. The plates are made of numerous roughened lead bands somewhat similar to the old Kabath accumulator. They are formed electrically, as in a Planté cell, but in forming, he adds to the sulphuric acid a chemical compound by means of which he claims to be able to form them completely in a day. This chemical is probably a nitrate, being a modification of the well-known method of adding a little nitric acid in forming. In the Schoop accumulator (Oerlikon), of the Faure type, the current is led off from the top of the positive plates and from the bottom of the negatives, by which means it is claimed that the current will be collected more symmetrically, and thus prevent the objectionable warping and buckeling of the plates. In large plates the current is led off from all four corners of the positives, and from the middle of the negatives. The cells are filled with soluble glass in the form of thick jelly, with which the acid is mixed, the object of the jelly being apparently that of a sort of porous plate. On account of this jelly it appears to require double the surface of plates for the same current. In the Pollak accumulator, of the Planté type, the plates are made of a sheet of lead having numerous little rods of lead perpendicular to its surface. The active material, in the form of chemically prepared lead, is put on the surfaces between these little rods which are afterwards bent over at their ends, forming hooks which hold the active material on the plate. These accumulators are said to give about 3 to 3.5 ampere hours per pound of plates.

An interesting detail in the Faure-Sellon-Volkmar, or E. P. S. accumulator, is that each positive plate is permanently connected to the negative of the next cell by having one curved lug in common, which is cast onto the two plates. These two cells are connected by having their individual plates connected. This affords a very simple means for connecting a series of cells without the objectionable clamps or mercury contacts, but it makes it awkward to take out and replace a "sick" cell. Their large cells are of 1,250 ampere hours capacity, giving about 5 ampere hours per pound of plates at a rate of discharge of about .6 to .7 amperes per pound of plates. These are about the average value of accumulators of this class, that is, with pasted grids; for those of the Planté type the capacity per pound of plates is usually lower, while the rate of discharge is higher.

The accumulator of the Société Anonyme pour le Travail Electrique des Métaux differs from most others in the fact that the grid is cast around blocks of active material. These blocks are made by casting melted lead chloride into iron moulds, forming flat blocks about an inch and a half square, with rounded edges. A number of these are then placed in the flat mould in which the lead grid is then cast, thereby firmly locking these blocks in the lead grid. The active material is then formed as in an ordinary pasted cell. The plates are usually very large. They claim to get about 4½ ampere hours per pound of plate at a rate of discharge of about .5 amperes per pound.

Among the accumulators of historic interest in the exposition are the first, second and third types of 1879-'80-'81 respectively, of Faure, the last two of which are the ones usually illustrated in text-books. In the exhibit of Gaston Planté there is also a series of historically interesting cells of his type.

There is much of interest in the French section in "galvano-plastics," but as the processes in such cases are usually (and wisely too) kept a secret, nothing more than a mere mention of the exhibits can be given here. Christofel has by far the finest and best exhibit in this class, including life size statues in copper, ornaments of all sorts in different metals and in numerous shades of bronzes, solid silver ornaments, etc. Beauferay has some excellent exhibits of all kinds, principally flat plaques, plates, clock dials, etc., on the different parts of which designs are electroplated with different colored metals and oxide of metals, producing very artistic effects. Still other effects are produced, for instance in clock dials, by painting the design with some insulating material and etching the background by making it the anode of a bath instead of the cathode, thereby leaving the design raised. Another exhibitor colors metallic objects electrolytically with any or all the primary colors of the spectrum. It is probably a thin coating of copper oxide, and it appears that he can color any object with any one desired color. The color

appears to be permanent, being an oxide, but it probably is too thin to stand wear. Iron plating, and ingots of electrolytic iron are also exhibited. Numerous objects are exhibited which are plated with magnetic oxide of iron. It is nearly the same color as oxidized silver and is very hard, and therefore very durable. Being already an oxide it does not rust or tarnish. Magniny exhibits numerous objects of non-conducting materials coated with copper and other metals; among them are objects of glass and wood, plaster statues, moldings, wicker baskets, ribbons, bouquets of natural flowers, leaves, straw hats, mosses, and even chairs and tables. The coating is strong and not brittle, and the surface is clean and smooth. Roseleur exhibits a bath for silver-plated spoons in which the spoons are suspended from an arm of a balance, which when the required amount of silver has been deposited, automatically breaks the circuit.

In the exhibits of primary batteries for lighting, the principal feature seems to be to provide means for supplying a continuous stream of fresh liquid in the top of the cell and drawing off the used liquid at the bottom. The battery almost exclusively used is the zinc-carbon bichromate cell.

Many of the arc lights here are far superior to ours in steadiness; flickering and hissing being the exception here instead of the rule. It may be of interest to add that very few, if any, use the clutch and drop feed.

There is a semi-incandescent lamp here, which, if it is as efficient as the result of certain experiments seem to show, will doubtless have a notable future. It consists essentially of two horizontal rods in the same line, separated from each other by a short space, and a vertical carbon rod resting with its lower end on these two copper rods. The current enters at one copper rod and passes through the end of the carbon across to the other copper rod, thereby heating the end of the carbon to a white heat, giving a steady white light resembling the arc light. As the carbon is consumed it descends gradually by its own weight. It requires from 8 to 12 volts. There being no regulator of any kind, the lamp is simple and cheap.

The International Electrical Congress was in session here from the 24th to the 31st of August. A considerable number of countries were represented, but the total number of foreigners was not large. There were only about 10 or 12 active members from the United States. Germany was not represented at all. A large number of papers were read and discussed, the Congress being for this purpose divided into four sections:—1. Units and Measures; 2. Industrial Application; 3. Telegraphy, Telephony and Signals; 4. Electro-physiology. The second section had the largest representation. Among the conclusions reached were the following:—The *Joule* was adopted as the practical unit of work, being the energy generated by an ampere through an ohm. The *Watt* was adopted as the unit of power; it is equal to a Joule per second. It was decided to express the power of a machine in *kilo-watts*[1] in place of horse-powers. It was decided to adopt as the unit of light the *decimal candle*, which is equal to the $\frac{1}{20}$th of the absolute standard adopted in 1884, and is very nearly equal to the English standard candle, and is $\frac{1}{10}$th of a carcel.

It was decided to adopt a practical unit of induction equal to 10^9 and call it a *quadrant;* to adopt the word *period* of an alternating current for the duration of one complete oscillation; to adopt the word *frequence* for the number of periods per second; to define the mean intensity of all alternating currents by

$$I_{mean} = \frac{1}{T}\int_0^T I\,dt;$$

to call the square root of the square of the mean intensity of current the *effective intensity;* to call the square root of the square of the mean electromotive forces the *effective electromotive force;* to call the factor by which the effective intensity must be multiplied in order to give the effective electromotive force the *apparent resistance;* to call the *positive plate of an accumulator*[2] that which is connected to the *positive pole of the machine* during charge, and which is the positive pole during discharge. The Congress recommended as a means of determining the degree of incandescence of a lamp the method proposed by M. Crova and adopted by the 2d section. It was agreed to adopt the metallic (double-fil) circuit for telephone lines in cities and between cities (inter-urbain). To signify by the word inter-urbain all telephone connection between two subscribers or public stations, forming parts of different groups.

Paris, September 6th, 1889.

1. 1 kilowatt = 1.3406 h. p. = 1.3592 metric h. p. = 44,239.4 foot pounds per minute = 6,116.22 kilogrammeters per minute.
1 h. p. = .74594 kilowatts.

2. The peroxide plate.

ON HERTZ'S EXPERIMENTS.[1]

BY M. JOUBERT.

Dr. Hertz, professor at Carlsruhe, published in the course of the year 1888–1889 some experiments of very great interest. I have repeated the greater number of them, with the assistance of M. de Nerville, at the Central Laboratory of Electricity in the Place Saint Charles. The large hall at the laboratory, which forms a rectangle of 15 meters by 14 meters, enabled me to reproduce them under very favorable conditions.[2]

The great interest of M. Hertz's experiments lies in the accurate information that we gain from them concerning the intervention of the external medium in electrical phenomena. The idea of this intervention is not new. After Faraday's experiments and Maxwell's theories, there remained no doubts upon this point in the minds of physicists; but the experimental proof was wanting, and this proof has now been given to us by M. Hertz's experiments. They show, in particular, that the medium which intervenes in electrical phenomena is the same ether that forms the seat of luminous phenomena; that the disturbances in both kinds are set up under the same conditions, and with the same rapidity; and lastly, that there is identity of nature between certain electrical phenomena and the luminous phenomena.

What is an electrical current? We do not know; but the following hypothesis gives us a very good idea of what occurs. Let us consider a conducting wire as connected to indefinite elastic cords, radiating from all parts of its surface. The passage of a current displaces the wire in a line parallel to itself and in the direction of the current, so as to draw with it the points of attachment of all the cords. These latter become oblique and remain oblique while the current is passing, but return to their original position and resume their normal direction as soon as it ceases. These cords being indefinite, the effect of the current makes itself felt at any distance, but evidently less and less, in proportion as the distance is increased.

But it is also very evident that the effect is not felt everywhere at the same moment; it arriyes progressively at the various points, and takes rather more than eight minutes to arrive at the sun. We may add that what is called the *co-efficient of self-induction* is only the co-efficient of the term that corresponds to this external work of the creation of the field.

It should be well understood that the phenomenon of which I have just spoken has not its analogy in luminous phenomena. In order to produce the resemblance, we must

1. Bulletin de la Société Internationale des Electriciens, July, 1889. Translated in *Electrical Review*, London.

2. The materials necessary for these experiments were very kindly supplied to us by Messrs. Carpentier and Lemonnier, and by the company for working metals by electricity. I take this opportunity of thanking them for their generous assistance. I must also express my sincere thanks to the young engineers at the laboratory, Messrs Marganie, Dierman and Bary, for the help they rendered us throughout.

consider alternating currents. Let us introduce into our rectilineal conductor an alternating current of a sinusoidal form; the elastic cords will be drawn alternately into first one direction and then the other, and each one will be the seat of transverse vibrations propagated along its length. We will, according to custom, call length of undulation the path taken by the movement during a complete vibration backwards and forwards. It is under the action of these movements, transmitted through ether, that a conducting wire, stretched parallel to the first, becomes the seat of induction currents. We may remark that if this wire is stretched at a distance from the first equal to the length of undulation, it will give, at about the same intensity, the same phenomena of induction as if it were in contact; but that if it were placed at half this distance, *i.e.*, at a distance equal to a half length of undulation, the induced movements would be at each moment of a nature contrary to those produced in a wire adjoining the conducting wire, the only ones that we are accustomed to consider, and that the elementary laws of direct and inverse currents would be reversed.

The experimental verification of this fact would be the most direct proof of the propagation of the electric action; but if the rate of propagation is the same as that of light, viz., 300,000 kilometers per second, and if the period of our alternating current be $\frac{1}{100}$th of a second, the wave length will be 3,000 kilometers, and the distance of the two wires would be 1,500 kilometers.

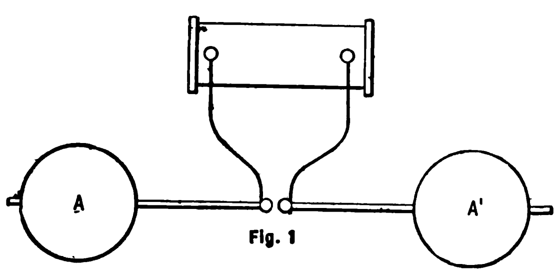


Fig. 1

In order to get a wave length of 3 meters the duration of the vibration must not exceed $\frac{1}{100000000}$th of a second.

We cannot hope to produce directly alternating currents of such a short period; but we know that under certain conditions of resistance of the circuit the discharge of the Leyden jar is effected by isochronous vibrations of very short duration; but these oscillations have always been found to range from $\frac{1}{10000}$th to $\frac{1}{100000}$th of a second. It is the same with the oscillations produced in the open circuit of the secondary wire of a Ruhmkorff coil at each interuption of the inducing current. This minimum duration of $\frac{1}{100000}$th of a second corresponds to a wave length of three kilometers!

One of M. Hertz's great achievements is to have found a method by which still more rapid oscillations can be given, the duration of which may be reckoned in billionths of a second. Theory points out that if two spheres (figure 1) charged at different potentials are put in communication by a conductor, equilibrium is established by a series of isochronous oscillations, rapidly checked, like those of a liquid contained in communicating tubes, the level of which has been disturbed. The duration of the oscillation depends on the capacity, C, and the co-efficient of self-induction, L, of the system, and is given, when the resistance of the joining wire may be disregarded, by the formula

$$T = 2\pi\sqrt{L\,C}.$$

Such is briefly M. Hertz's apparatus, which we will call the exciter; it consists essentially of a rectilineal conductor cut in the middle and terminated at its extremities by two large spheres or two plates of large surface.

In the apparatus placed before the Society the rectilineal conductor has a diameter of .5 centimeters and a length of 40 centimeters; the two spheres are 30 centimeters in diameter. Consequently we get

$$C = \frac{15}{9.10^{20}},$$
$$L = 400$$
$$T = 16.10^{-9}$$

From this we deduce for the length of undulation, the speed being supposed to be that of light,

$$\lambda = 4.80 \text{ meters.}$$

In order to effect the instantaneous charging of the exciter we leave an interruption in the middle, terminating the two opposite extremities by little balls, and putting each of these balls into permanent communication with the two poles of a Ruhmkorff coil. The bobbin employed with the exciter in question is a Carpentier bobbin (type 600 fr.) working with a Marcel-Deprez interrupter, and a current which is 15 amperes when the interruption is suppressed.

This is the action of the apparatus. At the moment when induction is produced on the secondary wire of the coil the two branches of the exciter which form the extremities are brought to different potentials, and at the same instant a bright spark flashes between the two balls, establishing during a very short period between these two balls a passage of low resistance, across which the rectilineal conductor discharges upon itself independently, almost as if it were separated from the bobbin. These oscillations are stopped before the following oscillation of the bobbin, which does not return until after $\frac{1}{10000}$th of a second has elapsed, and they are renewed in the same manner at each oscillation of the bobbin. The condition of the exciter may be compared to that of a violin string, the vibrations of which are kept up by the sharp drawing of the bow.

The essential condition of the phenomenon is, therefore, that the spark should pass and should be of the intensity required. If we separate the balls so as to suppress it and to leave open the secondary wire of the bobbin, we no longer get the proper oscillations of the bobbin, which are about 10,000 times slower than the proper oscillations of the exciter.

The production of rapid oscillations depends on complex and even somewhat mysterious conditions; they are influenced not only by the distance of the two balls, but also by the condition of the surface, the degree of polish of these balls, the dimensions of the bobbin, the strength of the inducing current, etc.: a pretty strong violet light falling upon the balls completely puts a stop to the oscillations.

We know whether the apparatus is working well by the report and aspect of the spark; this spark is formed of very fine and very bright rectilinear strokes, giving rise to sharp crepitations.

The exciter naturally develops in the neighboring conductors alternating induced currents. I established experimentally, in 1880 (Comptes Rendus de l' Académie des Sciences, vol. xci., pp. 408 and 493, 1880), the laws of alternating currents. I showed in particular, that the circuit seemed to have, instead of its resistance, R (the *true resistance*), an *apparent resistance* equal to

$$\sqrt{R^2 + \frac{4\,\pi^2\,L^2}{T^2}}.$$

In actual experiments, in consequence of the excessive smallness of T, the second term of the radical takes an enormous value, before which the proper resistance of the conductor may absolutely be disregarded. And thence arise several necessary consequences which impart to the phenomenon quite a special character.

In the first place the resistance of the conductor is of no importance; all else being equal, the phenomena produced in a wire will be independent of the nature and thickness of the wire. In the second place, there will be established between two neighboring points of the same conductor, which are separated by an apparent resistance which may

be enormous, differences of potential out of all proportion to those that we generally observe. Lastly, that property of variable currents of penetrating only progressively the thick layers of the conductor will be carried to its extreme, and the electrical movements will be solely superficial.

In fact, when the apparatus is working well, as at present, and the oscillations are produced, there is not in the room or in the adjoining apartments any piece of metal, large or small, insulated or in communication with the earth, from which we cannot draw sparks. We see them flash between the two extremities of a wire which we curve into a bow, between two pieces of money, or two keys that we bring together; we obtain them by presenting the point of a knife from the gas pipes, water pipes, etc.

In order to analyze this phenomenon M. Hertz uses a wire bent into a ring, the extremities of which can be brought together at will. We observe the sparks which pass between the extremities of the wire, and we judge of the intensity of the phenomenon by the striking distance and by the brilliancy of the spark. On trying rings with different diameters we find one with which the sparks take their maximum length; it is then that the period of the electrical movement excited in the wire which constitutes the ring is the same as that of the exciter; the ring acts as resonator. And, in fact, if we take a frame of the same diameter, but in which the wire makes several turns, we obtain much feebler sparks.

With a resonator well in accord the sparks are from 8 to 10 millimeters in the neighborhood of the exciter; they decrease rapidly when the distance increases, but they are still visible at 15 or 20 meters from the apparatus.

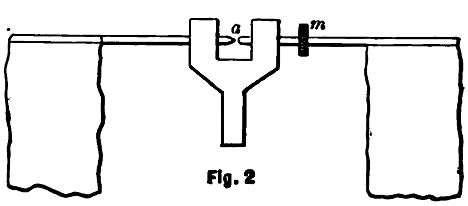


Fig. 2

I hoped to render these phenomena visible to an audience by employing a frog, but the frog gives absolutely nothing.

Instead of M. Hertz's ring, M. de Nerville and I have employed a rectilinear resonator composed of two rods, formed of two copper wires, placed end to end, the extremities of which bear sheets of tin for capacity (figure 2).

We determine by trial the length of the wires and size of the sheets of tin most suited to our purpose. At the interruption, *a*, one of the wires is rounded, and the other cut to a point. The system constitutes a species of micrometer; one of the wires bears a screw-thread, and the sparking distance is made to vary by turning the milled head, *m*.

The spark flashes in the space between the two wires. When the exciter is working in the large hall of the laboratory, and the length of the wires and the size of the tin plates of the resonator are well regulated, we observe very brilliant sparks, of seven or eight millimeters, in the neighborhood of the exciter, and they are still visible when the resonator is removed into the other halls, into the yard or street, even to a distance of 50 meters, several walls intervening.

This apparatus leads us to a very curious experiment, showing plainly the influence of light on the production of the oscillations. On bringing the resonator near to the exciter, we see that the character of the spark of the exciter changes, and at the same time the spark of the resonator disappears. On interposing any screen whatever, the phenomenon reappears in all its brilliancy. A sheet of glass has the same effect as an opaque screen; but, on the contrary, the interposition of a thin sheet of quartz, which allows a violet light to pass through, does not re-establish the phenomenon. The spark of the rectilinear resonator is at its maximum when the resonator is parallel to the exciter. The spark is nil when the resonator is in the symmetrical plane of the exciter, but when turned a few degrees we see the spark reappear.

A stone wall acts in the same way as a transparent plate as regards the undulations, and we can hardly note any difference between the sparks obtained on the different sides of the wall. A metallic plate acts like a glass very slightly silvered; it reflects part of the wave, but lets a very considerable part pass through; thus the sparks are still very appreciable behind a metallic surface formed of a sheet of tin or a plate of zinc of .5 millimeters, or even of a plate of iron of 3 millimeters. These figures are simply the thicknesses of the plates tried, and they have no other meaning. It is probable that we should obtain a more complete reflection with plates of greater thickness or greater conductivity.

I come now to one of M. Hertz's fundamental experiments; that which demonstrates in an undeniable manner the existence of the waves in question. It is an experiment exactly analogous to that by which Savart showed the interference of direct sound waves with waves reflected by a wall. The wall of one end of the hall was covered with plates of zinc, forming a metallic surface of four by six meters, and the exciter was placed opposite to it at the other end.

The vibratory movements provoked by the exciter are reflected from the metallic surface. By well-known mechanism, the reflected waves, interfering with the direct ones, give rise to stationary waves separated by fixed nodes. And, in fact, if we place the resonator very near the wall we only see faint sparks; they increase when it is drawn away, attain a maximum, then go on decreasing and finally disappear at a distance of about 2.4 meters, to reappear again. Thus, there is a first node in contact with the wall, as is the case with sound waves when the reflection takes place with change of sign, and a second at a distance of 2.4 meters. The distance corresponds to half a wave length. If we take in the duration of the vibration as calculated above, *i.e.*, 16 billionths of a second, we deduce from it that the rate of propagation is 300,000 kilometers, *i.e.*, that of light.

Thus the vibratory electrical movements, and the vibratory luminous movements, are propagated with the same rapidity. They answer, then, to a modification of the same nature of the same medium. The only difference is in the duration of the period. We can easily obtain electrical vibrations of a billionth of a second, and consequently wave lengths of 30 centimeters. The length of undulation of the visible rays is on an average 00.005 centimeters; that is, 600,000 times shorter. M. Hertz carried still further the analogy between the two phenomena, and we have repeated the greater number of his experiments. Unfortunately, they are too delicate to be shown in public, and I can only invite the members of the Society to come and see them at the laboratory in the Place Saint Charles.[3] I will now merely indicate the principle of them. An exciter with a very short period is placed according to the focal line of a parabolic cylinder, having a height of two meters, with an opening of 1.20 meters.[4]

The area in which the phenomenon is appreciable, and in which sparks can be obtained with the resonator, is limited by two vertical planes passing through the edges of the mirrors, and parallel to the axis of the parabola of the base. We get thus a true parallel electric ray, similar to the luminous ray that would be given by a source of light placed in the position of the exciter. By receiving this ray upon a second mirror, similar to the first, we may repeat the well-known experiment of the two conjugate mirrors, and show that the vibratory movement is concentrated upon the focal line of the second mirror. We may also reflect this ray upon a plane, and show that the angle

3. An extra *séance* took place at the Place Saint Charles on Friday, July 12th, for the repetition of these experiments.

4. We are indebted for these mirrors to the kindess of M. Lemonnier.

of incidence is equal to the angle of reflection. We may also make it pass through a prism, show that it deviates towards the base of the prism, and from the deviation deduce the index of refraction of the substance for the electric ray. M. Hertz made this last experiment with a prism of asphalt. This is the only one that we have not been able to repeat, for want of a prism of sufficient dimensions.

The President warmly thanked M. Joubert, and congratulated him upon the charm which he has imparted to his communication upon a subject of the highest scientific interest. He adds that the members of the Society ought to congratulate themselves on the fact that their laboratory has enabled these remarkable experiments to be realized.

THE MEASUREMENT OF SELF-INDUCTION BY THE TELEPHONE.[1]

When the current in a conductor changes, whether it be by a change in the E. M. F. or of the resistance, or both, it never happens that this occurs suddenly, but always in such a manner that the current gradually increases or decreases from the initial to the final value *through all* the intermediately lying points.

This phenomenon, it is believed, is caused by an especial E. M. F. which acts only so long as a change in the current takes place, and disappears when the current has reached a stationary value. Every current during the change in its intensity, induces in neighboring conductors, and in its own conductor, an E. M. F. The induction in its own conductor is called self-induction; this is always so directed that it works against the current by which it was called forth.

This phenomenon is of the greatest importance in every branch of electrotechnics in which currents of variable intensity or direction are used, for instance, especially important in telegraphy, for operating signaling and printing apparatus, or in telephony in operating the speaking and hearing apparatus.

If a current impulse be sent through a conductor connected with a signaling apparatus, at the moment of making the connection the self-induction will be the greatest, and consequently the current the weakest. Within a very short time the current and self-induction will respectively increase and decrease, and if the circuit be closed long enough, the current will attain a constant value independent of the self-induction, and can be calculated from Ohm's law.

This action is represented in figure 1 by curve 1, which begins in time *o* with a value o, and soon reaches the value at which the signaling apparatus will just work (dotted line), it then passes this value to reach another at which it can be kept constant, and which can be determined by Ohm's law.

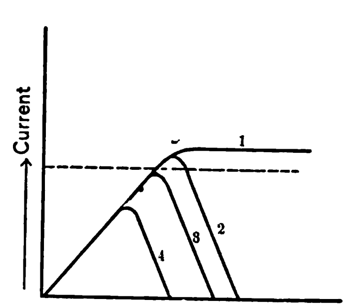


Fig. 1

Just how long the contact must be preserved that the constant value of current may be reached, depends very largely upon the amount of self-induction of the conductor and apparatus. If the contact is kept but a short time, the highest value reached will be less than that calculated by Ohm's law (see curves 2, 3 and 4). The greater the self-induction in conductor and apparatus, the greater will be the retarding and weakening of the current, and consequently the more slowly will it be necessary to telegraph.

Quite the same thing occurs in the action of a telephone line. Here the currents of alternating direction and varying volume may produce considerable weakening, it being a familiar fact that where a telephone is connected with a wire on which are many other instruments, it is at times impossible to understand the person with whom one is talking. A very valuable contribution in respect to the effect of self-induction on the sound in the telephone was made by Dr. Frölich at a late meeting of the Verein. If I now speak upon the same subject, I ask indulgence on the ground that one method not always answers to every case, and that it is often of value to regard a subject from different sides.

At the instigation of the government Post Office, the investigation of the self-induction in telegraphic conductors was undertaken by the Bureau of Telegraphic Engineering in Berlin. Many of the well-known methods were tried, but all proved too roundabout and too inconvenient. Among the methods tried was that given by Hughes in 1886, by which a telephone was used as the measuring instrument. I mention this method especially, not because it was finally employed but because of its essential feature—the use of a telephone.

The method employed was as follows:—

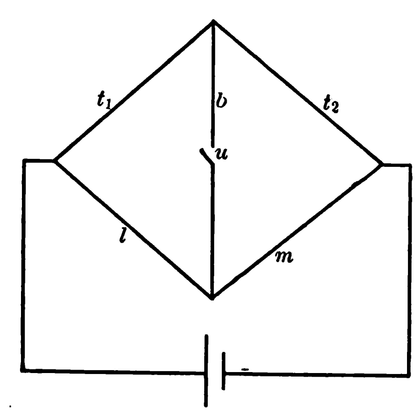


Fig. 2

1. If, in a Wheatstone bridge, figure 2, we have four resistances, t_1, t_2, l and m, and we send a current from the battery branch, then with a certain relation of these resistances the wire b will be without current. In this condition it is quite immaterial whether the wire b be opened or closed. If we take as t_1 and t_2 the windings of a telephone, then the opening or closing of the wire b at u will no longer be heard when $t_1 : t_2 = l : m$. We will now take t_1 and t_2, equal to each other and large in comparison with l and m; we will further make the bridge branch, b, of very small resistance; now the opening or closing of u (a revolving interrupter) will not be heard when l and m are equal.

2. After l and m are in this way made equal, transfer the interrupter from the bridge b to the battery wire (in the figure drawn for convenience below the parallelogram) and close b, figure 3. Now we will again be able to hear the opening and closing of u.

If, however, we take as t_1 and t_2 the two coils of a differential telephone, we can again make the sound disappear. A differential telephone is made by winding simultaneously two wires as the coils of an ordinary telephone. If an equal alternating current be passed through the wires in opposite directions, no sound will be heard.

1. A lecture by Over-Telegraph Engineer, Dr. K. Strecker, of the Bureau of Telegraph Engineers, of the German post-office. Translated from the *Centralblatt für Electrotechnik*.

3. The sound will remain unheard if l and m have equally great self-induction; that is if, under otherwise equal circumstances, an increasing current be equally retarded in both. For, in this case, the whole current in the system remains symmetrical to the bridge b; through the latter no current flows, and the current in t_1 and t_2 remains at every instant equal.

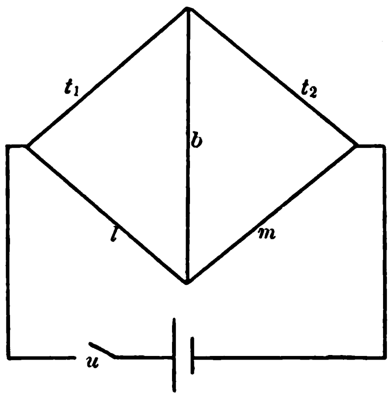


Fig. 3

4. The sound, however, immediately reappears as soon as l and m have different self-induction.

Assume l always to possess the greater self-induction. Then we can regard the self-induction in l as consisting of two parts, one part being equal to the self-induction in m. As far as this part is concerned no sound is heard in the telephone.

The second part of the self-induction in l, which is equal to the whole of that in l minus that in m, works like an E. M. F. of variable intensity and direction in the circuit $l\ t_1\ b$, and will be heard in the differential telephone.

Now in order to avoid this tone, it is necessary to introduce new E. M. F. forces.

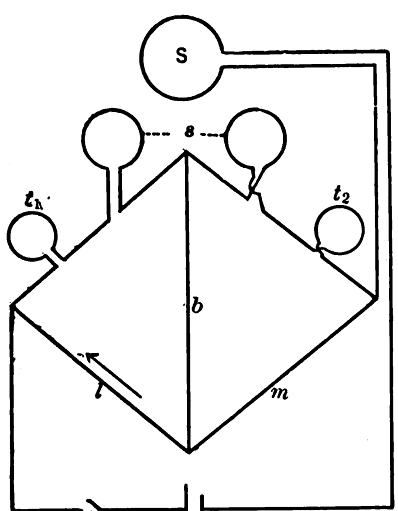


Fig. 4

We now insert in each branch a coil of wire. The two coils are exactly similar in dimension and resistance; figure 4. The double coil *s* is exposed to the inducing influence of the coil S, through which the main current flows. S and *s* are fastened upon the same support; S is fixed, but *s* can be brought into the plane of S and there revolved about its axis. The current passing through S and opened and closed at u, produces in each half of *s* an induction whose curve depends upon the angle which the two coils S and *s* make with each other; since these two halves of S are rigidly connected with each other the induction will always be the same in each. The induction has the greatest value when the plane of the coils coincides with that of S, and is equal to o when at right angles. If the diameter of S is great compared with that of *s*, then the induction is proportional to the sine of the angle that *s* has been moved from the right angle position. Under other conditions of radii we have another law. For a small apparatus whose coils had diameters of 16.5 and 12 cm. respectively for S and *s*, the induction was nearly proportional to the angle itself. Now should the induction from *s* working in the branch $l\ t_1\ b$ be opposite to that in l, then from the fact that at the moment of closing the current they flow in like manner, they will at every instant weaken each other.

The second half of S is to be connected with t_2 in such a manner that the induction in this half in reference to the winding of the telephone, has the same direction as that in the first half. Since then these two inductions support each other in their working upon the telephone, so at every moment do they oppose the self-induction in l. By a favorable choice of coils and of the angle which they make with each other, we can make the influence of the self-induction in the telephone disappear—this will be indicated of course by the disappearance of the sound. Then this difference of the self-induction in l is equal to the mutual induction of the main current coil S and the two branch coils *s*. Since *s* can be revolved about an axis in the plane of S, we have a means of altering the induction to an extent, as we have found, of ten or fifteen fold without experiencing any considerable loss in accuracy. Further change in the induction can be reached by altering the number of turns on coils S and *s*.

The graduation of an apparatus, as also the absolute measurement of the mutual induction of S and *s* can easily be made by means of a galvanometer. The resistance of m must be so chosen that its self-induction is small compared with that in l. With such an apparatus as this we can at once compare self-inductions, or after the constant is determined, make absolute measurements.

Of the two apparatus used, one was made up of such instruments as are to be found about any laboratory. The diameter of coil S was 44 cm. while the double coil *s* was a differential galvanometer of 2,000 turns in coils 7.5 cm. diameter. In measuring with this piece of apparatus, we followed the law of using the sine of the angle of deflection from the right angle position, which gave us great exactness in results. When the coil S had had only one turn, it was possible to measure the self-induction in a copper wire 4 meters long and 1 mm. in diameter.

With this instrument there was measured:—

When S had 10 turns, a steel wire 40 m. long and 2.3 mm. diameter (nearly 200,000 absolute units); with 50 turns on S, bronze and iron conductors 135 m. long and 1 to 3 mm. diameter (320,000 to 1,000,000 absolute units); and with 200 turns on S, four galvanometer coils of 100 turns, singly and in series (500,000 to 2,000,000 absolute units).

The second apparatus had in the main current coil 651 turns and in *s* twice 1006 turns; the diameters being respectively 16.5 and 12 cm. In this apparatus the spools were made removable so that they might be replaced by others of different numbers of turns.

In order the better to show the application of this method, I give below examples of actual measurements.

The self-induction of two coils of the same length of wire and section, is dependent upon the form of the section. A wire and a band, both of copper and having the same sectional area (the band being composed of a number of copper wires 0.1 mm. in diameter and clamped together side by side), gave values for their respective self-induction differing by 20%., the higher value being for the wire. The question of the influence of the form of section may be of importance in the construction of lightning conductors.

Kind of Wire.	Current Altered. From	To	Self-induction co-efficient in million absolute units.
Iron 1.7 mm....	0.	0.015	1.10
	0.	0.025	1.10
	0.	0.095	1.12
	0.087	0.095	1.10
	0.42	0.43	1.06
	0.87	0.91	1.07
	1.06	1.13	1.05
	2.15	2.20	1.07
Bronze 1.2 mm.	0.	0.10	0.372
	0.81	0.89	0.370
	2.26	2.40	0.372
Bronze 3 mm....	0.	0.03	0.317

2. Wires of bronze and iron were stretched in a yard and fastened to porcelain clamps, the wire forming a rectangle 59m.x 8.8m. and kept as far as possible from all metallic conductors. The whole length of wire was 135 m. The self-induction was investigated by various currents, but with the higher ones the contact was not broken, the current being varied by regularly introducing and removing resistances.

A discussion of the curves obtained in this experiment would be perhaps too precipitate, as here the iron showed a self-induction of three times that of copper. The measurements, on the iron were, to say the least, uncertain, as it was impossible to obtain or at least to recognize a complete disappearance or minimum in the tone in the telephone. The number of the interruptions per second was not determined; these however varied between so wide limits that their influence upon the alternations undoubtedly should have been regarded.

3. A steel wire 40 m. long and 2.3 mm. diameter was next investigated by various currents.

E. M. F. Used.	Resistance Changed. From	To	Self-induction co-efficient in million absolute units.
volts.	ohms.	∞	
1	9.33		0.210
45	139.	155.	0.200
45	85.	93.5	0.194
45	46.	51.2	0.188
45	20.	21.6	0.195
45	10.	10.4	0.173
45	7.	7.2	0.173
45	139.	155.	0.169

Here is shown a great dependence of the self-induction upon the current. It will be seen in the last measurement that the steel wire was greatly changed by the preceding current, this alteration consisting probably in a permanent magnetization.

4. An attempt to measure the self-induction in an iron wire of the Berlin telephone net was unsuccessful; and our attempt corroborated our earlier conclusion, that this method is not adapted for measurements on iron wire. On the other hand, our experience supports us in the belief that the method is excellent for determining the self-induction in all other conducting materials. We are still busy investigating the possibilities of this method, and at a later opportunity will return with our results.

I have thus early communicated what has up to the present been done in this investigation, thinking that my communication might be of interest or of practical value to some members during the Verein's vacation, so near at hand. The gentlemen who will themselves try this method, will always find me ready to give more exact information, and they will always be welcome to inspect the apparatus and connections in the Bureau of Telegraphic Engineering in Berlin.

ABSTRACTS AND EXTRACTS.

INSULATION RESISTANCE OF ELECTRIC LIGHTING INSTALLATIONS.[1]

When the industry of electric lighting was first beginning to assume importance, electrical engineers did not consider it necessary to measure accurately the insulation resistance of any part of their work; but experience has since then shown that good uniform insulation resistance throughout an installation is necessary, and cannot be obtained without careful attention to detail and a rigorous system of testing. The terms usually employed in regard to the insulation resistance of an electric light installation are, that it shall be "good" or "perfect," according to the fancy of the party purchasing the plant or of his adviser. These terms have, however, no specific meaning, and are therefore very variously interpreted; but the following points will be readily admitted in regard to insulation resistance of electric lighting installations: 1. That owing to the comparatively low resistance of the conductor circuit of ordinary electric light installations on the parallel incandescent system, the minimum standard of insulation resistance does not require to be nearly so high per unit of length as in the case of submarine cables. 2. That it should be directly proportional to the E. M. F. of the generator, or difference of potential between the conductor and earth, or between the forward and return conductors. 3. That it should be inversely proportional to the total length of insulated conductor, or to the total current, or to the number of lamps in circuit. 4. That whatever rules or standards of insulation resistance may be adopted, they should be applied, not only to all the conducting wires, but also to the dynamo, the lamps, and all the fittings, or, in other words, to the whole circuit.

In May, 1882, in the first set of "Rules and Regulations for the Prevention of Fire Risks arising from Electric Lighting," issued by the Society of Telegraph Engineers, no standard of insulation resistance or of minimum leakage is recommended. About 1883 or 1884, however, the admiralty officials requested that the insulation resistance of the dynamos supplied to them should withstand the test of stroking the free end of a conducting wire (the other end being connected to either pole) over any part of the framing, without showing any signs of sparking when the machine was driven at its normal speed; and the only test applied by contractors when wiring an installation was, and often still is, that of simply inserting an ordinary lineman's detector or galvanometer between a battery and the leads, with the other end or ends freed. If the galvanometer gives no deflection, or a very small one, then the section is passed. This is such an exceedingly simple and handy test for workmen, that it can scarcely be improved upon, but it gives no precise indication whatever of the resistance in ohms, of the dielectric, or of the fittings. It simply informs the observer whether there is a bad fault or not. He can also find out by it whether the continuity of the conductor is complete, by earthing the further end, and can ascertain whether there is a short circuit or not between any two or more "forward" and "return" leads by suitably varying the connections.

In 1884, whilst testing the electric light wires and fittings of some ships, the author first drew up his rule, which has been published in the last three editions of Munro & Jamieson's "Pocket Book of Electrical Rules and Tables." He had previously tested the insulation resistance of a number of land and ship installations, and was rather surprised at the variety and lowness of the dielectric resistance. At first he could not get contractors to come up to his rule; but now, when care and attention to cleanliness in jointing, to the fixing of wires and fittings, as well as in the manufacture of dynamos, are observed, he has fre-

1. Abstract of a paper read by Professor A. Jamieson, F. R. S. E., M. Inst. C. E., before the Institution of Electrical Engineers.

quently found that the insulation exceeded the demands of his rule, which is as follows: "A careful insulation resistance test of each circuit, and finally of the whole of the circuits (including all switches and terminals, but not necessarily the lamps) joined up together, should be taken, and not passed unless the resistance is at least equal to $.1\Omega$ per lamp for every volt employed. The insulation resistance of the dynamo coils should be equally good."

Put into formula shape, the rule is:—

$$R_1 = k\frac{E}{N},$$

where R_1 = the total insulation resistance of the whole or any part of the lamp circuits or of the generator in ohms;

k = a constant ($.1\,\Omega = \frac{1}{10}\Omega = 100{,}000\ \omega$) found from actual tests of several well erected installations;

E = E. M. F. of dynamo or installation in volts;

N_L = number of lamps, 16 c. p., on each circuit or on the whole circuit.

The insulation resistance is therefore here taken to be directly proportional to the normal E. M. F. of the dynamo, and inversely proportional to the number of 16 c. p. lamps in circuit. The difficulty of ascertaining the precise length of the mains, sub-mains, leads, and dynamo windings led the author to substitute the number of lamps in circuit for what might at first sight appear to be the more exact term in the denominator, viz., the length of conducting wires employed. Although not stated in the above quotation of his rule, the author usually applies the same test for the resistance or percentage leakage of current between the whole system of forward and return wires; also between the dynamo armature with field magnet coils in circuit and the frame or body of the machine, as well as between the series and shunt magnet coils if the dynamo is of the compound or series shunt type.

The following table gives the insulation resistance for 16 c. p. lamp circuits and dynamos:—

No of lamps in circuit.	50-volt lamps. Ohms.	65-volt lamps. Ohms.	80-volt lamps. Ohms.	100-volt lamps. Ohms.	110-volt lamps. Ohms.
1	5,000,000	6,500,000	8,000,000	10,000,000	11,000,000
10	500,000	650,000	800,000	1,000,000	1,100,000
20	250,000	325,000	400,000	500,000	550,000
40	125,000	162,500	200,000	250,000	750,000
50	100,000	130,000	160.000	200,000	275,000
100	50,000	65,000	80,000	100,000	110,000
150	33,333	43,333	53,333	66,666	73,333
200	25,000	32,500	40,000	50,000	55,000
300	16,666	21,666	26,666	33,333	36,666
400	12,500	16,250	20,000	25,000	27,500
500	10,000	13,000	16,000	20,000	22,000
1000	5,000	6,500	8,000	10,000	11,000

The leakage allowed in the case of 100-volt lamps, using .64 ampere of current per lamp, is $\frac{1}{100000}$ ampere for every lamp in circuit, or the percentage leakage is .0016 per cent. Since by the above rule the dynamo requires to have the same insulation resistance as the lamp circuit, the insulation resistance of the whole circuit, including the dynamo, is half of that given by the formula and tables, and therefore the leakage is double, or .0032 per cent.

In November, 1888, in the 14th edition of the Phœnix Fire Office Rules, Mr. Heaphy has added a table based upon similar proportions. (It may be observed that the above table corresponds identically with the author's rule for an E. M. F. of 125 volts; *e. g.*, take 100 lamps: then

$$R_1 = k\frac{E}{N_L} = 100{,}000\ \omega\,\frac{125\ v}{100\ L} = 125{,}000 \text{ ohms};$$

and so on in proportion to the number of lamps.) His rule No. 27 reads as follows: In any electric light installation in which the current is continuous, and has an E. M. F. of 200 volts or under, the insulation resistance over the whole installation should not be below the following:—

Installations of 25	lights	....	500,000 ohms.
" 50	"	....	250,000 "
" 100	"	....	125,000 "
" 500	"	....	25,000 "
" 1,000	"	....	12,500 "

On November 7, 1888, M. Picou communicated his rule to the International Society of Electricians. According to this, the insulation resistance is

$$R_1 = k\frac{E}{C}.$$

The differences between M. Picou's rule and the author's lie in the different values given to the constant k, and in the substitution by M. Picou of the total current C for the total number of lamps N_L in the author's rule. There is no doubt an advantage in thus substituting C for N_L, since the constant k thereby expresses directly the number of times the insulation resistance is of the apparent working resistance, $\frac{E}{C}$; and its reciprocal, the proportion which the leakage current bears to the total current; but M. Picou's constant, $k = 500$, is by far too low to insure good and lasting work. By it a circuit of 1,000 lamps of 16 c. p. each, requiring 100 volts and .64 ampere each, the total insulation resistance of the circuit would only need to be 78.1 ohms, instead of 10,000 ohms by the author's rule.

In April, 1888, this Institution issued its second pamphlet of "Rules and Regulations for the Prevention of Fire Risks," and rule 16 states that "the insulation of a system of distribution should be such that the greatest leakage from any conductor to earth (and in the case of parallel working from one conductor to the other when all branches are switched on, but lamps, motors, etc., removed) does not exceed $\frac{1}{1000}$th part of the total current intended for the supply of said lamps, motors, etc.; the test being made at the usual working E. M. F. This rule includes all kinds and systems of electrical installations, and it is very neatly and concisely expressed. It gives a constant 10 times as great as M. Picou's, and about one-tenth that of the author's rule.

The ordinary Wheatstone bridge test is the handiest and easiest method of ascertaining the actual resistance in ohms of the conductors, as well as of the insulation resistance. Should the insulation, however, be too high for the battery power and the galvanometer, then the direct deflection substitution method may be adopted. These tests are so fully described in every book on testing, and are, besides, so well known, that there is no need to explain them here. The battery power need only be a few Leclanché cells (10 or 12 at most) if the galvanometer used is of the sensitive mirror Thomson type. When the installation has been completed, then the whole of the results may be obtained by means of ordinary ampere and voltmeters. First put the the ampere meter in series with the main leads, and join the voltmeter across. Work the installation at its normal power, and observe the total current C, and the difference of potential E. This gives us $\frac{E}{C}$. Then join the voltmeter with one side to earth, having previously ascertained its resistance r, ohms. Also note C on the ampere meter, and see that it is the same as before. If any leakage to earth exists in the dynamo, or in any part of the circuit, a deflection on the voltmeter will be produced corresponding to the leakage current c passing through it, which is represented by e volts difference of potential between its terminals. Then $\frac{e}{r} = c$, the total leakage current. But $\frac{C}{c} = k$, the actual constant or co-

efficient of the insulation resistance of the system. Then, if this value is greater than k, our standard constant, the installation may be considered satisfactory as far as insulation resistance is concerned; but this test does not inform us if any leakage is taking place between the forward and the return system of wires, or between the shunt and the series windings of the dynamo. To ascertain the former of these, disconnect all the lamps and insert the voltmeter first in the forward lead, and secondly in the return lead, and note if we get any leakage current c when the dynamo is run at its normal speed. In regard to leakage between the shunt and series windings of the dynamo magnets, recourse must be had to the Wheatstone bridge test.

ALTERNATE CURRENT WORKING.[1]

BY W. M. MORDEY.

(Concluded from page 366.)

SECONDARY E. M. F. OF TRANSFORMERS.

THE best potential difference to be used on transformer circuits has been a good deal discussed, especially with reference to the voltage of lamps. It is very desirable to arrive at some conclusions on this matter, not only as to glow lamps, but as to the general question.

The balance of opinion—which is, however, not very decisive—appears to be in favor of using 50-volt rather than 100-volt lamps, so far as durability of the lamp is concerned. The stout low-tension filament should last longer than the finer one for high tension, because disintegration does not so soon reduce the cross section to the breaking point. It is, however, not a question only of life, as the disintegration of the thick filament causes blackening of the globe; and if it can be shown that this blackening, and the consequent lowering of the effective light, is more serious than in 100-volt lamps, then the advantage of slightly longer life will not of itself be sufficient to recommend 50-volt lamps in preference to others of higher voltage.

Of course, the most serious objection to lowering the voltage is the increased cost of the secondary conductors. This is not important in small and very compact installations such as can be so readily supplied by transformers—for instance, in small shops and ordinary houses, where a separate transformer may be placed within a few yards of the lamps, and where the fall of potential is negligible; but for larger work it is advisable to keep the potential difference high, as with direct currents, and for the additional reason that the use of very large alternate currents, with correspondingly large conductors, is accompanied by the inconveniences arising from the high virtual resistance already alluded to.

It is impossible, however, to choose an E. M. F. that will meet all requirements. For instance, high candle-power lamps are coming largely into use, and as this practice extends, higher E. M. F. will be demanded in order to keep down the diameter of the "stick."

But, on the other hand, lamps of small candle-power can be more easily made for low than for high voltage; and as there is a growing tendency to use small candle-power lamps which in many situations give all the light that is required, this point should be kept in mind, especially as it is very probable that before long a demand will spring up for lamps of three or four candles. I know it will be said that it is easy to reduce the candle-power of ordinary lamps by inserting an impedance coil in the circuit. This is one of the many conveniences of transformer working, but it should not be resorted to for permanent purposes, as, however little power such a coil may absorb, lamps reduced in that way, being worked at less than their normal candle-power, are very inefficient.

Then there is another reason for sometimes preferring 50 volts to 100 volts that I should like to mention, and that is that alternate current arc lamps do not require more than 50 volts terminal pressure. It may be expected that many such lamps will be used on transformers—for instance, at small business places, where perhaps the bulk of the lighting will be internal and by incandescence lamps, but where it will be convenient to have one or two arcs outside. We know that when arcs are used in parallel with incandescence lamps on direct current circuits, it is necessary, in order to get the best results, to have 12 to 15 volts drop of pressure in a fixed resistance in series with each arc. Thus has arisen the custom of using 65 volts for mixed arc and glow lamp circuits, where the potential difference at the arc lamp terminals is reduced to about 50 volts by the insertion of such a resistance, the incandescence lamps, however, being made to work at 65 volts.

This is a very wasteful arrangement; but, apart from its wastefulness, 65 volts is a very inconvenient pressure, both from the manufacturer's and the consumer's point of view. It does not lend itself to combination as does a pressure of 50 volt dynamos, lamps, or transformers, for 65 volts cannot be used in pairs on 100-volt circuits as can such apparatus for 50 volts. It is an irregular and inconvenient pressure that is demanded by the necessities of direct currents, but that, I am glad to be able to say, need not be imported into alternate current work.

This very serious loss can be almost entirely avoided with alternate current arcs, as the necessary steadying effect is readily obtained by the use of an impedance coil, absorbing much less power than does a resistance; and as such arcs require only 35 to 40 volts between the carbons, instead of 45 to 50 with direct currents, it is sufficient to provide 50 volts potential difference between the secondary conductors.

But it may be said that, as impedance coils absorb little power, the arc lamps may be put on 100-volt circuits in parallel. This may be done without much objection so far as the lamp and impedance coil are concerned, but there is the drawback that the "plant efficiency" of the transformer will then be low.

The output of a transformer is limited partly by the size of the conductor. The actual output of a 100-volt transformer supplying arcs through impedance coils will not be much more than the product of the current $\times$ 50 volts, while for the same output in watts on glow lamps it would only have to yield about half the current. Therefore we see that, although not inefficient, the maximum allowable output of a 100-volt transformer on parallel arc lamps is only about one-half of its ordinary maximum output.

It will be said that two arcs may be run in series on the 100-volt secondary. This is true, but two arcs are not always wanted; and further, the working of two arcs (which must for this purpose be shunt or differential instead of simply series wound) in series on a constant potential difference is the least satisfactory way of arranging arcs, whether for direct or alternate current, as in this way they affect one another the most; having neither the margin of controlling power, by current, which is provided in the parallel constant potential difference arrangement; nor by E. M. F., as in the series constant current arrangement. Then, again, lamps so connected must be extinguished together, as no cut-out or switch can be used unless it is made to insert a resistance or impedance to take the place of the extinguished lamp.

On the whole, therefore, it is preferable to have 50-volt secondaries where arcs are to be used, or to adopt the intermediate plan of connecting the middle of the 100-volt secondary to a third terminal, using a third wire for any arcs or 50-volt lamps that may be required. It may be worth while to point out that the use of a third wire on transformer circuits may lead to difficulty if not carefully considered. With a single transformer it is as easy to use three or any other number of terminals for the lamps as it is to do so on a set of accumulators, and to get any corresponding potential difference. The various sections of the secondary may be unequally loaded by this arrangement, but the primary responds as a whole to the demand made upon it. If, however, instead of a single transformer, two transformers are used, with their primaries and secondaries respectively in series, then the use of the three-wire principle is only possible when it is applied to both the primary and secondary circuits, unless the load on each of the two secondaries is always to be alike and the same, in which case, as scarcely need be said, there is no particular advantage in using three wires. If the loads are not equal on the two, then the primary of the least loaded transformer acts as an impedance coil to the other primary, and all power of self-regulation is lost. One remedy for this is to apply the three-wire principle to the primary as well as to the secondary; but this is a serious matter, and one that could only be undertaken where the whole service demanded it. Another plan is to have two mains for the primary and three for the secondary, and to join the primaries parallel, the secondaries being in series with the third wire at the middle terminal.

In cases where arcs have not to be used, and in the absence of any very strong evidence of any difference of life in favor of 50-volt lamps, I think it is best to use 50 volts for small separate installations, and 100 volts for larger ones; but it is evident from what has been said that there are so many points to consider that it is quite impossible to give any definite negative or affirmative reply to the question, "What is the best secondary E. M. F. to use?" Each case, or at least each class of cases, must be settled on its merits. If for general convenience any particular pressure is selected, it is obvious that it will have about equally strong arguments for and against it.

ALTERNATE CURRENT ARCS.

Reverting to this subject, it is to be regretted that very little appears to be commonly known about A. C. arcs. I trust that in the discussion of this paper some information may be furnished with regard to them.

As to the regulating mechanism of lamps, although some difficulties were encountered in modifying the Brush arc lamp for this work, the result has been perfectly satisfactory; the feeding range is very small—quite as small as with direct currents, and with no greater loss of power in the lamp box. Some trouble was experienced in getting rid of noise and vibration

1. A paper read before the Institution of Electrical Engineers, London, May 23d, 1889.

in the coils and mechanism, but this has been completely overcome, the lamp itself being quite silent. This is readily proved by connecting the carbon-holders by a flexible wire and adjusting the current to the normal value, when it is found that there is no noise. An A. C. arc is not silent, as is well known, a distinct hum being set up, by which it is quite possible to ascertain the periodicity.

This humming noise, which can scarcely be expected to be overcome, renders A. C. arcs unsuited for general use indoors; but for outside illumination, and for such places as railway stations, they will certainly find a very extensive application.

I venture to think that the opinion so often expressed, that A. C. arcs give much less light than those supplied with direct current, is founded on a misunderstanding of the proper conditions. It is quite true that if two arcs are compared, supplied with the same amount of current, the direct-current lamp will prove the better one. This, I think, is because the basis of comparison is not right. In many cases the A. C. arcs are more efficient. They should be judged by the energy, and not only by the current. I have mentioned that an A. C. arc requires only 35 to 40 volts potential difference between the carbons, while a direct-current arc requires 45 to 50 volts. The mean may be taken at 37.5 volts and 47.5 volts respectively, and to expend the same energy in the two cases the current should therefore be in the inverse ratio of these values. Thus an A. C. arc, to give the same light and to absorb the same power as a 10-ampere direct-current arc, should be made for 12.6 amperes.

In one respect A. C. arcs are inferior, and that is in their power of directing the light downwards. They have no "crater," and therefore do not send the light down as do direct-current arcs. On this account it is advisable to use reflectors above them, unless they are suspended below and near a good reflecting ceiling or roof.

But even this drawback is counteracted in parallel work by their greater efficiency. On a 65-volt circuit with direct currents, as I mention elsewhere, there is a waste of 100 to 150 watts with a 10-ampere arc, and in the same proportion with other currents. This is a very serious proportion of the whole power, and it is only allowable to waste it because, as a light-producer, the arc is so much more efficient than the incandescence lamp. Nevertheless, any means of avoiding the loss is to be welcomed, and with A. C. arcs it may be greatly reduced by the use of impedance coils, which, if properly designed, waste very little power, and have all the steadying effect of resistances.

SAFETY AND SAFEGUARDS.

I take this opportunity of bringing up this question, not because I have anything new to say with regard to it, but in order, if possible, to bring it a little nearer to a rational settlement.

It will be acknowledged that the first duty of an "undertaker" using high tension is to provide for the complete and absolute safety of the consumers. If there are no means of doing this, then the system is fundamentally bad, and must sooner or later be abandoned.

There are several ways of protecting the house mains more or less completely. I only need allude to three typical plans, all of which have already been discussed before this Institution.

One is the plan introduced by Mr. Kent, of entirely separating the primary and secondary conductors in a transformer by a sheet or division of earth-connected metal. This is open to adverse criticism on some points, but on the whole it is an effective plan.

Another arrangement is the ingenious one of Captain Cardew, consisting of a sort of static mouse trap, which immediately goes off when an unauthorized P. D. enters it.

The third plan is that of earthing the secondary, and it would be very instructive if those who so strongly oppose this plan would state just one real objection to it. It is a perfectly sure method, and costs nothing.

It renders it absolutely impossible for the consumer to get a dangerous shock under any possible combination of circumstances whatever.

The faults that may occur are:—

(*a*) Contact between primary main or mains and earth.

(*b*) Contact between primary and secondary in a transformer.

(*c*) Contact between a person and a portion of the secondary conductor.

(*d*) Contact between that person and earth.

Now if all these contacts occur at the same time, the "person" will get a shock.

But if the secondary is earthed, no shock can be obtained, except, perhaps, a slight one due to the secondary P. D.

This simple plan has been approved by almost everybody, but it is received with opposition on the part of some of the fire insurance offices and others.

It is difficult to ascertain where the supposed danger is. If the secondary is earthed, the effect of a contact between primary and secondary, when the former is accidentally leaky, is at once to blow out the primary safety fuse of the transformer, and so cut out the offending house. This is the simplest and the best course to take, and prevents the continuance on the circuit of transformers that contain faults.

The Brush corporation has adopted this plan with perfect success on a large installation abroad, and intends adhering to it where local circumstances permit.

It is to be remarked that it is not open to the objection that has been stated against earthing of one of the primary conductors, viz., that the telephones may be affected, for it is not permanent. The moment a contact occurs that could lead to a disturbance of the telephones, the fuse prevents that disturbance being continued.

While effectually removing life risks, this precaution does not increase fire risks; in fact, it tends to greater safety, as it is some sort of check on the character of the house wiring work, and so reduces chances of faults such as short circuiting of the secondary.

The rupture of a primary safety fuse is not a serious matter, and in any case it is only what takes place under ordinary circumstances when any fault occurs that results in an excess of current.

As to static effects, I think it will be found that there will always be enough general leakage to prevent such effects being a cause of difficulty, even if the secondary circuits are not earthed.

HYSTERESIS AND EDDY CURRENTS.

Some explanation is necessary by way of preface to this section of the paper. The experiments described were made with a direct current dynamo, and on that account they only touch the fringe of this division of the subject. As I had no suitable alternator, I was unable to pursue the question as far as I wished to do, but I hope I need make no apology for bringing forward such results as I have been able to arrive at.

As far as I am aware, no simple or practical method is known by which the power absorbed in eddy currents can be determined and separated from that due to hysteresis in the armatures of dynamos. This is a point of some importance both as regards alternators and direct current machines, for many reasons; one of the principal being that in the absence of extra knowledge on these matters it is difficult or impossible to determine to what extent the lamination of the iron cores should be carried. There are wide differences in the practice of the various designers and makers of dynamos in the thickness of the iron used.

Lamination may be carried to such a degree of fineness for the purpose of reducing eddy-currents as to add very materially to the cost of production, the iron increasing rapidly in price as the thickness is reduced; and it may be that the point is sometimes passed beyond which no gain in efficiency is obtained. This is a question we wish to be enabled to settle.

Until Professor Ewing[1] and Dr. J. Hopkinson[2] read their Royal Society papers on the subject, very little was known of the heating effect of changes of magnetism. Professor Ewing opens the part of his paper dealing with this matter in the following terms (p. 552, *Phil. Trans.*):—

"The energy expended in a cyclic process of magnetization can take no other form than that of heat diffused throughout the substance of the metal. Experiments have been made by Joule and others to determine by direct observation the heating effect of magnetization in iron.[3]

"In most direct measurements of this quantity no distinction is made between the heating effect due to the induction of electric currents and that due to changes of magnetization *per se*; and so excellent an authority as Professor Rowland, writing in 1881, has expressed himself as doubtful whether changes of magnetization, considered apart from the currents they induce, give rise to any development of heat at all."

Further on, Professor Ewing, referring to the dissipation of energy by hysteresis, which he had determined by laboratory experiments, says (*Phil. Trans.*, pp. 553, 554):—

"These developments of heat are so small as to make it apparent that the very considerable thermal effects which reversals of magnetism cause in the revolving cores of some dynamo-electric machines must be due almost wholly to the internal induction of currents, so far as they are not due directly to the current circulating in the coils of the armature.

"The experiments have a practical value in showing that cores which are so thoroughly laminated as to render the induction of currents within them unimportant, do not involve any serious loss of energy; and that the efficiency of a machine with a soft iron core or cores whose magnetism is periodically reversed need not, on that account, be materially less than that of a machine which has no such cores. The absence of iron from the armature has been claimed, on the score of efficiency, as an important advantage possessed by some types of machine, but unless the claim has some other basis it appears to me to be illusory. Magnetic reversal does involve some loss of energy, but if the cores are properly laminated it is so small as to be practically insignificant."

I quote these passages as showing the position of the question; Professor Ewing and Dr. Hopkinson give laboratory determinations of the magnetic loss in iron with various inductions, and

1. Professor Ewing, "Experimental Researches in Magnetism," *Phil. Trans.*, January, 1885.
2. Dr. J. Hopkinson, "Magnetization of Iron," *Phil. Trans.*, April, 1885.
3. Joule, *Phil. Mag.*, vol. xxiii., 1843; Grove, *Phil. Mag.*, vol. xxxv., 1849; Villari, *Nuovo Cimento*, 1870; Cazin, *Ann. de Chem. et de Phys.*, 1875; Trowbridge, *Proc. Amer. Acad. of Arts and Science*, 1879.

under various conditions. It is, however, left somewhat in doubt as to whether the loss in dynamo armatures will be the same as in the laboratory experiments, the conditions being very different in the two cases.

On this point Professor Ewing shows that hysteresis is much less when the iron is in a state of mechanical vibration than when it is in a state of rest, and states that in a dynamo the loss will be less than the experiments on still metal might lead us to expect.

Another way in which the dynamo conditions may cause some difference is the possible variations of the magnetic density that may exist in the core. Such variation may be considerable in armatures of large size.

Dr. Hopkinson (*Phil. Trans.*, p. 467) takes the magnetic loss in armatures as being the same as in the small pieces of iron tested by his method, and gives an example calculated for an armature "finely divided, to avoid local electric currents."

It is to be noted, then, that both these authorities regarded eddy currents as unimportant in laminated armatures; but in the later paper on "Dynamo-electric Machinery,"[4] Drs. J. and E. Hopkinson published their famous investigation into the efficiency of dynamos, and gave very full particulars, from a study of which it is possible to ascertain the loss in eddies, on the assumption that the method of calculating the magnetic loss is correct when applied to armatures—a point which Dr. Hopkinson was not able to decide positively; but by assuming that it is applicable, then, by subtracting the calculated hysteresis loss from the ascertained total power unaccounted for, the eddy current loss is obtained; and as this process gives the hysteresis as accounting for only about 40 per cent. of the total loss in the armature core, it shows that the eddies could not by any means be considered unimportant, although the lamination was carried out to the extent of making the iron about 0.02 inches thick.

I now wish to describe a method by which the amount of loss due to each of the two causes may be ascertained experimentally in the workshop on a practical scale. It is a very simple one, although not, perhaps, capable in all cases of the highest scientific accuracy.

(*a*) First run the dynamo on open circuit at various speeds (two readings will suffice), with the fields unexcited, or, better still, entirely absent, and measure the power absorbed in friction. Plot this value to any suitable scale, as O M in figure 3, the ordi-

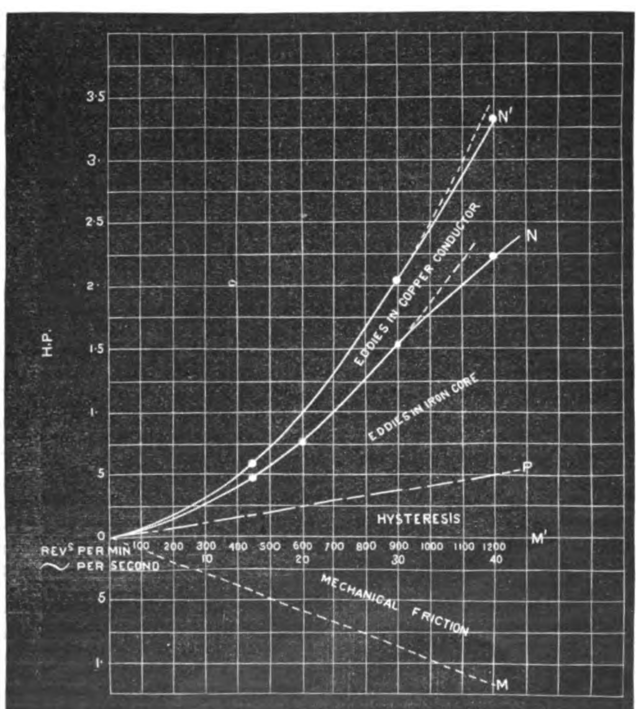


FIG. 3.

nates representing horse-power, while the abscissæ represent revolutions per minute.

In the figure the mechanical friction being a quantity with which in this investigation we are not directly concerned, is plotted below the base line, O M′, in order that the other losses may be more clearly seen.

(*b*) Next run again on open armature circuit, with the brushes removed, and the field normally excited, and measure the power absorbed. This will be the total power dissipated in friction, hysteresis, and eddy currents, if any, and must be plotted as O N.

Then the ordinates lying between O N and O M′ represent the sum of the losses due to hysteresis and eddy currents, and somewhere between O M′ and O N must lie a line, O P, separating the hysteresis from the eddy currents.

We desire to find the position of this line. The difference between the rate of increase of the electric and magnetic losses enables us to separate them from each other. It may be taken that, with any given constant excitation, the loss from hysteresis is directly proportional to speed, within certain limits to be hereafter stated. The resistance (that of the iron) being constant, the eddy currents must vary as the first power of the speed, and the loss therefrom as the square of the speed.[5]

It will now be seen that it is easy to separate the values which are directly proportional from those which are proportional to the square of the speed.

Professor S. P. Thompson, to whom I submitted this method, has kindly given me the following concise formulæ for finding the quantities:—

P and P_1 are respectively the combined magnetic and electric losses at the speeds S and S_1.

k — magnetic loss;

k_1 — electric loss;

$$k = \frac{P_1 S^2 - P S_1^2}{S^2 S_1 - S S_1^2};$$

$$k_1 = \frac{P S_1 - P_1 S}{S^2 S_1 - S S^2_1}.$$

Then, at any speed n,

Hysteresis $= k\,n$;

Eddies $= k_1\,n^2$.

If armature cores are run in an excited field before winding, it can be determined to what extent their lamination is satisfactory, and whether the iron is of good quality; and then, after winding the armature conductors, another test shows what the additional increase in the loss is, and separates the effects of eddy currents in the core from those in the conductor, and the hysteresis from both. The method may also be useful to investigate the losses in the cores of armatures of different types, or differently built up, as, for instance, with iron wire or iron sheets.

This method has a useful application in rendering it possible to separate not only the magnetic loss from the electric loss in the iron, but to determine the waste by eddies in the copper winding of armatures.

It is usually entirely a matter of opinion as to how much of the power absorbed in running an armature on open circuit is due to any of the various causes referred to; and now that it is customary to wind armatures with heavy conductors, it becomes very desirable to be able to find in any particular case what proportion of the loss is in the copper, and what in the iron.

In figure 3 are shown some results obtained with a four-pole (direct current) Victoria dynamo run at various speeds up to 1,200 revolutions per minute, with constant excitation. Power readings were taken by means of a White's transmission dynamometer, constructed by the Brush Corporation for the purpose of testing dynamos; and the horse-power absorbed in mechanical friction in dynamo, belt, and dynamometer was subtracted from the power spent electrically and magnetically.

To reduce errors in the dynamometer readings the dynamo was fitted with two pulleys, one twice the diameter of the other. This allowed of the dynamometer being run at the same speed, while two different speeds of the dynamo were obtained by changing the belt from one pulley to the other. Readings were taken at four speeds, viz., 450, 600, 900, and 1,200 revolutions per minute, corresponding to 15, 20, 30, and 40 ∿ per second. The position of O P, was readily found by "trial and error," this being a shorter process for a concrete instance than the application of the general formulæ. The assumption on which this method of testing is based was found to be correct up to 900 revolutions. The reading at the higher speed of 1,200 revolutions, or 40 ∿, shows that disturbing influences began to affect the results by reducing the rate of increase of the losses. The continuation of the curve O N in a full line shows the actual loss; while the continuation in a dotted line, which is a parabola on O P as an abscissa, shows what the loss would be if the rate of increase holding for low speeds were maintained.

This shows that this method is perfectly applicable to ordinary direct current machines—for instance, to two-pole dynamos up to 1,800 revolutions per minute, or 30 ∿ per second—but that it is less useful for alternators.

The disturbing causes are probably rather complicated. They may be due partly to self-induction in the circuits of the eddy-currents, to lower magnetization (although this effect, if present, is very slight, as was shown by the E. M. F. being almost perfectly proportional to speed), and to vibration. "Viscous hysteresis," if it exists, will raise the magnetic loss. There may be such an effect, in spite of the lowering of the curve, but it cannot be recognized, on account of the unknown variation of the eddies, at the

4. *Phil. Trans.*, part 1, 1886, p. 331

5. Professor Thompson's "Dynamo-Electric Machinery." Third Edition, page 102.

higher speed. Iron cored alternators working at high periodicities may be tested in the following way, which will give some approach to correct results :—Let the test be taken at a low speed (not more than 80 ∿). This will give the hysteresis per period, and the eddies at that speed. Then, if at any higher speed the E. M. F. is proportional to speed, it may be assumed that the magnetic induction is the same as before, and the hysteresis per period will at any rate not be less than at the lower speed. It may be more. The difference between the calculated hysteresis, O P, and the ascertained total loss, O N, will be the eddies; or, if viscous hysteresis is a fact, it will be extra loss due to viscosity plus that due to eddies.

Heating of the armature core, and consequent increase of the resistance of the iron, is not responsible for the bending down of the curve O N, in figure 3 (although it would have that effect under ordinary circumstances), as the experiments did not occupy sufficient time to allow of any sensible rise of temperature. The effect is probably very complex and obscure, but it is one that well deserves study, on account of its present industrial importance.

It should be stated that the dissipation of energy (which has been spoken of as being in the armature) may be partly in the field magnets. This was, however, not the case in the experiments referred to. The conditions necessary for the prevention or reduction of eddies in the iron of field magnets are now pretty generally understood,[6] but it should be observed that it is not by any means as easy to check such waste in alternators as in ordinary dynamos. It is both better and easier to prevent than to cure them.

If a good transmission dynamometer is not available, results almost, or perhaps quite, as good may be obtained by running the machine at various speeds by means of an electric motor, and measuring the power required by the motor—first with the fields of the machine unexcited, to get the mechanical friction, and then with the fields excited, to get the total loss. The motor should then be run alone, to find what is absorbed in driving it at various speeds. The increase in watts over these last values, with the internal losses in the motor conductors calculated out and subtracted, will give, with a very fair degree of accuracy, the energy dissipated in the machine under test.

The upper curve, O N′, was plotted from readings taken after the armature was wound, and the difference in the ordinates between O N and O N′ shows the eddy-current loss in the copper conductor at various speeds. This loss, like that of the eddy currents in the iron, rises as the square of the speed up to 900 revolutions, or 80 ∿, above which it rises rather less quickly. The full line O N shows the actual loss, the dotted line above it showing what it would be if the rate of increase were maintained. The difference is no doubt due to self-induction.

That the effect of self-induction is not noticeable unless the eddy currents are considerable is in accordance with experiments that I published some years ago in connection with the Brush dynamo.[7] The results then obtained are shown in figure 4. The straight line connects speed and the potential difference at the terminals with the laminated armature; the lower and slightly curved line shows the potential difference with the old form of

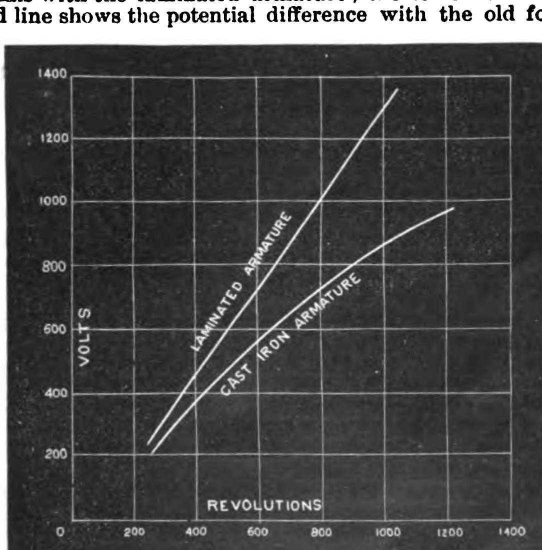


FIG. 4.

cast-iron armature, which had only coarse divisions, scarcely meriting the term "lamination." The curve shows that the E. M. F. rose less quickly than the speed on account of the serious generation of eddy currents.

In the laminated armature, although, of course, there were still eddies, their effect was not sufficient to cause any bending down of the E. M. F. line at any practicable speed of driving.

Coming now to an examination of the results obtained in the experiments, and shown in figure 3, we see that the hysteresis loss in this particular dynamo—which I should mention is capable of working continuously with a normal load of 18,000 watts—was 0.195 h. p. at 450 revolutions, and 0.39 h. p. at 9 0 revolutions, the latter corresponding to 80 ∿ per second.

The magnetization[8] was about 12,300 C. G. S. lines—not by any means a high density. The armature had a long core, nearly square in cross-section, of 12 square inches area, and contained 615 cubic inches, or 10,086 cubic centimeters of iron strip 0.012 inches thick (No. 30 B. W. G.) separated by paper. This is a degree of lamination beyond which it is inconvenient to go. The peripheral portion was wound with this iron in parallel bands one-half inch wide, in order to reduce eddies caused by lines entering the periphery. The main inner portion of the core was of wider strip.

We find from the figures that the loss in hysteresis at 900 revolutions was as follows :—

0.39 h. p. = 291 watts = 0.473 watts per cubic inch, or 0.029 watts per cubic centimeter. As the periodicity was 30, the dissipation of energy per complete period per cubic centimeter was 9,613 ergs, or 0.001 watts, nearly.

It is interesting to compare this result, obtained in what may seem a rather crude manner, with the values given in the papers referred to. Professor Ewing says(*Phil. Trans.*, page 553) "* * * the double reversal of a strong condition of magnetism in soft iron involves the expenditure of about 10,000 ergs per cubic centimeter." He gives the energy as 9,300 ergs, with a magnetization of 13,190 in very soft annealed iron. Dr. Hopkinson gives 13,356 ergs, with a magnetization of 18,250.

Much, of course, depends upon the quality and hardness of the iron, but my results come out very close to those of Professor Ewing and Dr. Hopkinson. This may be taken as proving the method capable of considerable accuracy. The eddies in the iron, it will be seen, are by no means to be neglected, even with the very fine subdivision that was used.

The eddies in the conductor are rather greater than usual, as the armature, being intended for a very low speed, had a larger amount of copper on it than usual.

The bearing of these curves on iron-cored alternators and on open circuit working generally is obvious. With a magnetization of 12,000, the loss in hysteresis alone, at 100 ∿, would be over 1.5 watts per cubic inch of iron core, and the eddies would amount to a good deal more. I will only add that the eddies, both in the iron and in the copper, are greatest when no external work is being done, as was the case in my experiments. They are reduced by the effects of self-induction when the circuit is closed. A difference exists in this respect between generators and motors, a difference in favor of generators.[9]

I will not further extend this paper by dealing at a greater length with this part of the subject.

APPENDIX.

Extract from remarks by Mr. Mordey in the discussion on Mr. Kapp's paper on "Alternate Current Machinery."—*Proc. Inst., C. E.*, March 5th, 1889.

"Alternators might be divided into two classes, those which had iron in the armatures, and those which had not. As his own machine, made by the Brush Corporation, and that of Ferranti were the only examples of the latter class described by the author, he might be permitted to mention the reasons which had led him to avoid the use of iron. He thought the makers of dynamos would agree that almost all the ills that the dynamo was heir to were due to the presence of the iron in the armature. Its use in direct current machines might be said to be a necessary evil, as, although attempts had been made to do without it, all successful types of such machines required it for structural purposes. Iron in armatures when worked at a high magnetic density, and with rapid reversals or variations of magnetisms, became heated and wasted a good deal of power. In alternators this objection applied with very much greater force than in direct current machines, for in the latter the reversals of magnetism were comparatively slow. Thus the first result arrived at in quite recent practice is that the magnetic density that can be used in iron-cored alternators must only be about one-half that employed in continuous current armatures. This alone meant a considerable increase in the size of armatures, without any gain in output or efficiency. Although the loss per cubic inch was reduced by decreasing the magnetic density, the armature had to be made larger to compensate for it, and the total loss was actually increased, not reduced. Iron was used to reduce the magnetic resistance, to afford mechanical support, and to introduce self-induction into the circuit. The latter, an evil in itself, was said to be a modern necessity, caused by the convenience of working alternators parallel. Self-induction,

6. See numerous practical notes on this subject scattered through Professor Thompson's "Dynamo-Electric Machinery."

7. The *Electrician*, October 2d, 1885.

8. The use of the word "induction" in so many senses is apt to cause confusion. "Magnetization" would perhaps be better than "induction," "magnetic induction," "density," "magnetic density," &c.

9. *Phil. Mag.*, January, 1886, page 26. "The Dynamo as a Generator and as a Motor."

for this or any other purpose, had probably not entered the minds of most designers at the time they first produced their machines, except, perhaps, as an objectionable feature, which they could not get rid of ; but now it was being brought forward as an advantage. If iron was indispensable for this purpose, which he was not prepared to admit, it could readily be inserted in some part of the circuit where ample space and cooling surface could be provided, and from which it could be easily removed when not required; that was when it was only necessary to run one machine. The armature was the very worst place to put the iron, for there its presence was the most objectionable, and it was there least under control. Referring to the magnetic resistance of armatures, it would be seen that there were broadly two ways of arranging the armature coils and the field poles. The poles could be arranged north and south, facing one another, the armature coils having their axes parallel to the lines of force; or the poles could be arranged in successive order round an iron ring or drum armature core, on which the armature coils were wound or placed. If iron cores were used in the former case, the output would be only about one-half of what was obtained with air cores, on account of the necessity to work with reduced magnetic density, while at the same time magnetic and electric disturbances would be set up, both in the armature and field, wasting power, causing objectionable heating, necessitating lamination of the fields, and demanding an increase in the exciting power. These reasons were sufficient to explain why he had not used iron cores; but there were others. Magnetic resistance, between pole and pole, was made up partly of the necessary clearance space, partly in most cases of the space occupied by the copper conductors, and partly of the iron or other core. Now, if in air-cored armatures the core could be so arranged, as was quite possible, and was done in his own machine, that it occupied no more space than was taken by twice the depth of the conductors in iron-cored armatures, it would be evident that the former gained instead of lost by the omission of iron. They gained not only in magnetic resistance, but in all the other points to which he had referred, and they had the very great advantage that there was nothing to limit the magnetic density at which they could be worked except the magnetic saturation of the field poles, the only losses to be met and provided for being the ordinary electrical losses in the conductor caused by the passage of the current, and a small waste by eddy currents in the conductors and supports. Such armatures had the further advantages that their self-induction was negligible, their power of self-regulation was very great, and that on open circuit or light load they ran very economically; whereas it was well known that, when iron cores were used, the losses under such circumstances were often very serious indeed. He thought it was quite unnecessary to use iron cores for the purpose of obtaining mechanical support for the armature winding. The holding and driving, with a very limited clearance, of an armature consisting of thin iron, separated by such unmechanical substances as paper, and overwound with copper wire, itself covered with cotton, and expanding and throwing out from the combined effects of heating and centrifugal action, was a problem that had never been very successfully solved in direct current machines, and was certainly to be avoided, if possible, under the still more onerous conditions obtaining in alternators, where the electrical pressure was usually much higher than in direct current machines, and in which, as the author showed, the maximum mechanical strain on the wires was greater. He ventured to think it was much the best to make the armature stationary as he had done. It then had only to resist the tangential drag of the field. He thought a great mistake was made in some alternators in using Pacinotti projections. In all cases there should be, as nearly as possible, a steady magnetic flux in the field. This could not be done if projections were used. The Zipernowski and Parson machines were faulty in this respect. It was impossible to tell, by inspection of the former, which was the armature and which the field. They seemed quite interchangeable, and this was, of course, not right. In these two machines it would be seen that the magnetic resistance varied very much, as the iron projections passed through the cycle. This necessarily led to losses in the field, the lamination of which recently introduced in the Zipernowski machine showing that such losses must be serious. There was one other machine to which he wished to allude, and that was to him a very interesting machine indeed. He referred to the alternator shown and referred to by Professor Forbes as in some respects a development of his alternator. In that machine Professor Forbes used the form of field which he (Mr. Mordey) had in his alternator; but he used it in combination with a form of armature having, like the field, only one coil. He ventured to point out that, for a machine with an iron armature, that form of alternator had some advantages. The armature might be described as a Gramme ring with the copper inside and the iron outside. The magnetic flux was, or might be made, perfectly even, the air gap was very short, the magnetic resistance very low, and it followed that the excitation required was very small. The author had alluded to a very interesting and important matter (probably new to most people, as it certainly was to him), namely, that the armature conductors in alternators showed a tendency to heat much more than in the continuous current machines, but in this machine described by Professor Forbes there was hardly any question of eddy currents in the armature conductor, as the coil was not swept by the lines of force. Further, it was evident that a very low current density could be used in the armature coil without sensibly affecting the size, cost, or output, and it was also clear that the insulation of the armature coil was a very simple matter. Another good point was that neither the armature coil nor the field coil need be rotated. For a machine with an iron magnetic circuit he thought this was a very good one; and he had only one other remark to make about it, and that was that he had himself invented and patented it some time ago! It was, he thought, a natural development of his alternator. He was glad to find that Professor Forbes had had the same idea, because that showed it to be a good one. Much had been said about the form of the wave yielded by alternators. He had some time ago made an experiment with the first of his machines, using the method described by Professor Ayrton, and found that the curve was almost a sine curve. On the subject of the lag in transformers, to which Professor Ayrton had also alluded, he might be allowed to mention that, in the discussion of another paper by the author, he had first stated the fact,[10] and had described a very simple experiment, showing that the primary and secondary currents reached their maxima and minima practically at the same time."

DISCUSSION OF MR. MORDEY'S PAPER ON ALTERNATE CURRENT WORKING.

[Abstract.]

THE discussion on Mr. Mordey's paper on the evening of May 30, 1889, was a very instructive one, and we regret that the pressure upon our columns will not permit us to report it in full; the following abstract, however, contains most of the salient points of the discussion, so far as possible in the language of the participants.

Professor JOHN HOPKINSON, who was absent, presented a communication, which was read by Professor George Forbes. Dr. Hopkinson said that some misapprehension might exist as to the conclusions which legitimately followed from the theory of running alternate-current generators in parallel, which he had given five or six years before. To obtain great control of one machine upon another, it was not in itself desirable to have great self-induction, as Messrs. Kapp and Forbes seemed to think, nor to have it as small as possible, as Mr. Mordey appeared to think; the machines would best control each other when $\frac{2\pi\gamma}{T}$, γ being the self-induction, was equal to the resistance of the armature circuit and the leads to the junction with the leads of the other machine. This was an obvious immediate consequence of the equation of paragraph 4 of his paper of November, 1884. If Mr. Mordey would add a substantial resistance, as of a feeder to the armature-circuit of each machine, he would find it less easy to run in parallel, but the difficulty would be somewhat diminished by adding a little self-induction to each armature-circuit. In paragraph 3 of the same paper, he had considered connecting a machine to a circuit of different potential, and had pointed out the limits within which such a machine would work as a motor. He then discussed the analogous problem of working two different machines of widely different fields connected together, as Mr. Mordey had done, and showed that his old theory was quite sufficient to predict all the results which had been obtained by Mr. Mordey in regard to running alternators in parallel.

Professor W. GRYLLS ADAMS presented a communication which was read by Professor S. P. Thompson. He said that the principles of parallel working had been established by Dr. Hopkinson in 1883, and that the first successful trial had been made in July, 1884, at the South Foreland Lighthouse with the De Meritens machines. In his paper, read November 13, 1884, he had established the fact that alternate machines worked in harmony without rigid connection, and that they governed one another by reaction, and also the fact, stated by Mr. Mordey, that the question of parallel working largely depended upon the synchronizing of alternate current motors. He had been much interested in Mr. Mordey's experiments, and would call attention to one or two facts. When one machine was running full speed, and the speed of the other gradually rising, the lamps were first fitful, then gave beats at first rapid and then slower, until the two were in harmony; the speeds were then in the ratio of 2 to 1. Of the eight experiments whose results were stated by Mr. Mordey, those numbered 1, 2, 3, 6 and 8, had been made in the experiments at the South Foreland in 1884; other experiments had been made at that time. The second machine had given off more than 4 h. p. on the friction brake; three machines had been driven in parallel until they synchronized and the belts thrown off two machines, which were then being driven as motors by the current from the third machine, the E. M. F. at the terminals of which remained unaltered. Three machines had also been driven

10. *Journal*, vol. xvii., pp. 215, 216.

parallel with the arc in the external circuit, the belt thrown off one machine, which continued to run as a motor, when the arc became steadier then when all three were driven from the engine; also the work done in the arc with two machines in parallel was considerably less then when two machines were supplying the arc, and at the same time driving the third machine as a motor.

The illumination given by the arc was (1) 13,500 candles, with two machines parallel; (2) 16,000 candles, with three machines parallel; (3) 17,800 candles, with two machines driving the third as a motor. To what cause could this synchronizing be attributed but to the self-induction of the circuit? Indeed, Mr. Mordey's experiment, in which he put two machines on the same circuit not in step, but running at same rate, showed that the self-induction was sufficient to synchronize them in an exceedingly short time, a circumstance, no doubt, due to the fact that there is very little iron in the armature.

Major P. CARDEW, R. E., referred to the question of the periodicity at which the temperature visibly follows the variation of current. Many years ago he had tried the Swan lamp for dot-and-dash signaling from a balloon, but found it necessary, in order to signal with sufficient rapidity, to short-circuit a resistance by the key, increasing the voltage at the terminals 20 per cent.; they could then get about twenty words a minute.

Mr. Mordey had given four possible contacts, *a*, *b*, *c*, *d*, and had said if all these occurred at the same time a person would get a shock. That was not quite the correct way to put it, because contact between the primary mains and earth was often unavoidable, and contact between the primary and secondary in a transformer might be on for minutes and nobody know it; so that contacts *a* and *b* are waiting for a person to make the third and fourth himself. Considering the effects of these machines it was worth while to take any justifiable precaution. Mr. Mordey saw no objection to the plan of earthing the secondary—that certainly avoided danger to life, but in respect to fire risks he was afraid it would not be so satisfactory. There was also no doubt that a connection to earth on a 100-volt circuit increased the fire risk, and no one really recommended it as a regular thing. (Mr. MORDEY, interrupting:—"I do.") Major Cardew continuing;—Mr. Mordey was perfectly consistent if he earthed a 100-volt circuit and did not consider that difference increased the danger of fire. If he could persuade the fire companies to that effect it would be all right. He had also understood that the Westinghouse company did earth the secondaries, but their representative distinctly denied it. He would like to know whether any American company did earth the secondaries or not?

Dr. J. A. FLEMING referred to the question of the life of lamps used with alternate or direct currents, saying he had made inquiries at Milan, where the systems were running side by side. There were two theatres lighted by alternate currents and others in the same vicinity by direct currents, and in all these theatres the lamp light was about the same. The regulation of the alternating system was, of course, very carefully attended to, as the company itself had to replace all lamps broken otherwise than mechanically.

Referring to the curves drawn by Mr. Mordey, he understood them to mean that with a periodicity of 100 per second the total heat in the transformers was less than at 125, or at 75. He would suggest that this is determined by the relative waste of energy by eddy currents and by viscous hysteresis. There was reason to believe that the waste due to hysteresis increased with the speed, and, therefore, at high speed, increased heat might be expected from this cause; on the other hand, at low frequencies the eddy currents permeated further into the iron and wasted more energy, hence at a certain frequency there must be a minimum of heating in the transformer core.

Mr. GISBERT KAPP expressed his high appreciation of Mr. Mordey's very interesting paper. He regarded it as one of the best contributions the society had ever had. The experimental facts brought out were of great value, but in estimating this value they should not allow themselves to be influenced by the author's attempt to use this fact in upsetting a well established theory. In this he had failed; but his facts were certainly of great importance. Mr. Mordey had quoted from a recent paper of the speaker's, in which he had said that self-induction was necessary to parallel working. Mr. Mordey, on the contrary, contends that the absence of self-induction and of resistance is the essential quality in an alternator, to make it synchronize and work as a motor, and his reasoning is apparently sound. He had shown the characteristic of one of his alternators, from which it appeared that self-induction only absorbed 2½ per cent. of the total E. M. F. and this alternator had then been put to work as a motor and the experiment had succeeded perfectly, from which he had concluded that a machine without self-induction would be the best possible motor. Among these experiments, however, was one which could not possibly have been performed had the machines been devoid of self-induction or some equivalent property. He referred to the coupling in parallel of two machines running at the same speed, one giving 2,000 and the other 1,000 volts terminal pressure. When these machines were put in parallel, the drop of the 2,000-volt machine was 500, the rise of the 1,000-volt machine 500 and the pressure in the external circuit 1,500. Now it was quite evident that in this case the characteristic of the generator could not have been the very flat curve shown in the author's diagram, in which the small drop of pressure (2½ per cent.) was supposed to be due to very small self-induction. The fall in pressure was some 25 per cent., which could not possibly be due to ohmic resistance, since this was small, and the author does not suggest that any large current traverses the machines. We are, therefore, confronted with this curious and inexplicable experiment:—Here was a machine supposed to have very little self-induction, giving a constant terminal pressure with a non-inductive resistance in the external circuit, but as soon as we used that machine as a generator in connection with a similar but weaker machine as a motor, there was a considerable drop. Now this drop could not be due to anything but self-induction or some equivalent property. As Mr. Mordey had merely recorded the experiment and not attempted to explain it, he would ask permission to make the attempt.

He was afraid that all of them who had worked with alternating current machinery had gone more or less wrong on the question of self-induction. In the first place, they had been in the habit of considering the armature without taking account of the influence of the field magnets; and second, they had not distinguished between self-induction proper and an equivalent property which might better be described as magnetic change. The armature, removed from its field magnets, has probably very little self-induction; it must, of course, have some, but when put into its field the self-induction must be considerably increased.

Now, if they would look at the diagram showing a section of the machine taken parallel to the shaft, and would consider only the coil shown between the two field poles, it might be regarded as a short solenoid, the two field pieces forming its iron core; obviously, in this position the coil must have great self-induction; the next coil lying between neighboring poles has a minimum of self-induction, as there is no iron circuit through it; the third coil would have a maximum, the fourth a minimum, and so on. Half the coils have, therefore, very great, and the other half very little self-induction. Now consider the position of the coils a quarter period later. One side of each coil is now between the polar faces, and the other side beyond them. Each coil could now be considered as a solenoid partially supplied with a core, and its self-induction must therefore be less than when coincident with the pole faces. Since, however, all the coils, not merely one-half, were now provided with cores, the self-induction of the armature as a whole must still be considerable. When the machine was working upon a non-inductive resistance, the self-induction (which, although subjected to periodic variation, could never be zero) was the principal cause of the 2½ per cent. drop in terminal pressure, as recorded in the paper. But when the machine supplies a circuit of sensible self-induction, another cause tending to lower the terminal pressure, which he had called magnetic change, comes into play. When there is little lag of current behind induced E. M. F., the maximum current through the armature occurs nearly at the time each coil is half covered by the polar faces. In this position the current through alternate coils tends to magnetize, and that through intermediate coils to demagnetize, the field poles, the two effects nearly eliminating each other. If, however, there is a considerable lag of current, the maximum occurs when each alternate coil is more nearly covered by the polar faces and the current tends to demagnetize the field. In a machine acting as a motor, the opposite takes place; the current in the coils facing the poles tends to strengthen their magnetism. Thus there is superimposed upon the effect due to self-induction proper, another effect due to magnetic change, which only comes in play if there is considerable lag. The field of the generating machine is weakened, and that of the motor machine strengthened, by the current traversing the armatures, and thus it is possible that the original pressure of the generator may drop 500 volts, and that of the motor rise by an equal amount.

Mr. J. SWINBURNE, while highly complimenting Mr. Mordey's paper, said that he disagreed entirely with his theory that his motor kept in step because it had no self-induction. Were this the case the generator would have no control over the motor at all. It seemed to him that electrical engineers did not altogether realize what was wanted in parallel running. It was perfectly well known that alternating machines tend to keep in step, but to make them run parallel commercially they needed a large margin of corrective tendency, which could only be obtained by so making the machines that the maximum current was not coincident in time with the maximum E. M. F. If the machines were working on resistance, this meant merely a smaller output; but if one machine was working another as a motor, the loss from resistance in the armatures was excessive in proportion to the power given out. The machines must be larger for a given output and also somewhat less efficient.

Mr. Mordey's attack on the existing theories seemed unwarranted. He makes experiments and gets results perfectly in accordance with existing theories; he then asserts that existing theories are wrong, without experimental evidence, and gives no theory of his own to take their place. That Mr. Mordey's machines have considerable self-induction is obvious from the

experiment with the 2,000 and 1,000 volt machines. He would not in the least undervalue Mr. Mordey's experiments, for the degree to which alternators can control one another was never fully realized until these results had been published.

Referring to the question of frequencies, Mr. Swinburne said that, generally speaking, in an armature of given size, in which a given waste of power, admitting of cooling by ventilation was allowed, a larger output can be got with a small frequency; he therefore preferred a very small frequency and thought Mr. Crompton would agree with him.

In comparing converters under different loads and conditions people were often misled by taking the same transformer in each case. The best for each particular use should be taken, to give results of value. He had recently made a large number of transformer calculations assuming an iron induction and a copper current density suitable for practical working. He had found that a 50-light transformer could be made to give 92 per cent. efficiency at 33 vibrations per second at full load. At 83 vibrations a 50-light transformer could give 93 per cent. The saving in cost of material was inappreciable.

As to lamination, he thought that Mr. Mordey had overestimated the effect of eddy currents. He thought they were generally inappreciable.

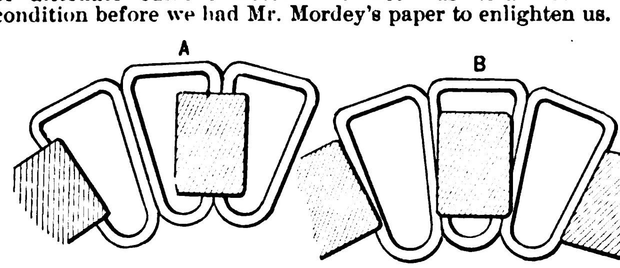
Professor S. P. THOMPSON, referring to Mr. Mordey's experiments and his statement that the foundation of parallel working should be that the prime motors "are under the control of the generators," said that those who saw the way in which that generator persevered in its work when the second generator was suddenly thrown upon it as a motor, could not help inquiring in what way the steam engine was governed. Mr. Mordey had rather startled the speaker by telling him that the steam engine had no governor. He thought that might account for some of the peculiarities of the experiments.

Mr. Mordey had pointed out that with alternating currents 50 volts were required for an arc lamp as against 60 volts with continuous current. Why was it that an arc lamp with a continuous current would not work well without at least the ordinary 60 volts? It was known that there was something in the arc which can be measured as counter E. M. F. He had employed students to investigate the position of this counter E. M. F. He had satisfied himself that in direct-current arcs the great drop of potential, usually 39 volts, occurred at the positive end or crater, and not in the arc itself, nor at the negative pole. There was a definite sort of polarization at the crater end. He had not yet examined alternate-current arcs, but expected to find some different disposition of the counter E. M. F. when the corresponding measurement came to be made.

Mr. Mordey had spoken of the drop in the characteristic curve of his machine as being partly due to resistance and partly to self-induction. He would rather express it that there was a drop in the curve due to resistance, a further drop due to the spurious addition to the resistance arising from self-induction, and a further drop due to the demagnetizing of the pole-pieces by the armature currents. But he was not at all sure that did not involve the question of self-induction, the self-induction of the armature and its demagnetizing effect being bound up together.

Mr. Kapp had said that the armature, apart from its field magnet, could have very little self-induction, but all that would change directly it was put in the massive iron circuit. He differed with him on that point. The current in a coil flying past at the rate of $\frac{1}{300}$th part of a second had no time to magnetize iron, and therefore could not produce appreciable self-induction.

He did not at all agree with Mr. Kapp that self-induction in the armature was necessary in order to produce stability, although he thought with him that self-induction outside the machine would tend to produce synchronism. Mr. Mordey's paper was distinguished for its perspicuous and conspicuous common sense. Ten years ago we did not know how to design direct current machines to run as direct current motors, but with better designs of generators came better understanding of motors. The subject of alternate current motor machines was in a most chaotic condition before we had Mr. Mordey's paper to enlighten us.



a, a, Armature coils. *b, b*, Field poles.

Professor W. E. AYRTON sincerely congratulated the author, and said that if he had done nothing more than experimentally confirm Dr. Hopkinson's mathematical conclusions an enormous debt was due him by electrical engineers. He then gave an account of experiments which had been made by his assistants respecting the self-induction of the Mordey armature in various positions. The greatest self-induction was found to be when every coil was partially covered by iron. It seemed that neither Mr. Kapp nor Professor Thompson were quite correct, for the co-efficient was 0.038 in position A (see figure) and 0.036 in position B; and both decreased about 14 per cent. when the magnets were fully excited. The frequency of the testing currents was about 100 in all the tests. He referred to the results of experiments conducted by students at the Central Institution on the efficiency of Mordey's transformer under varying frequencies and loads. So far with frequencies of 53, 80, 200, 240, and with loads varying up to the maximum intended load, they had obtained no indication whatever of the remarkable result stated by Mr. Mordey, that his transformer was more efficient for an intermediate than for a higher or lower frequency, but on the contrary had found that the efficiency increased steadily with the frequency.

Professor GEORGE FORBES said he would ask Mr. Mordey to make definite something which did not appear in the paper, but had come out in the discussion, namely, that in the experiments in parallel working there was no governor on the engine. He would like more information on this point, and thought it would explain many apparent anomalies.

He thought Mr. Mordey was perpetrating an error, common of late, in assuming only two means of distributing alternating currents, one by a single large machine, the other by a number of small machines in parallel. Many people thought too much had been said about American practice, but American practice had been to have a number of small machines, each district being supplied by separate mains and feeders. One dynamo had a number of feeders, but when the maximum current is on, with a small load, all these feeders may be put on one machine.

The president, Sir WILLIAM THOMSON, in closing the discussion, said that before calling on Mr. Mordey to reply, he would refer to that gentleman's beautiful experiment of coupling two alternators with respective potentials of 2,000 and 1,000 volts in parallel. He thought the secret of the result had not been quite touched by any of the speakers except Mr. Kapp. The 500 volts D. P. would, notwithstanding ohmic resistance and impedance by self-induction produce a current vastly greater than that found by experiment, in the absence of some counteracting influence. To find what this is, suppose the armature resistance to be zero and the two armatures to be joined ready for work. The shafts might be mechanically constrained to run synchronously so that the E. M. F. of the two armatures would conspire in the circuit. The 3,500 volts would produce a prodigous current, for all self-induction could do, but this current would enormously diminish the field magnetization and might even reverse the weaker one, and thus after first making the circuit of the armatures, the prodigous current would become much moderated, even supposing the initial phase-relation to be mechanically maintained. This was the phase-relation for series co-operation, and as shown by Hopkinson in 1885, could only be maintained by rigid mechanical connection. But in Mordey's experiment the shafts are independent, hence they fall into step co-phasally for parallel working. Their electromotive forces become thus exactly opposed in the circuit of the two armatures and would yield exactly 500 volts, and the working E. M. F. of the two field magnets remain unchanged. The ohmic resistance being still supposed zero, the phase of current kept going in virtue of the E. M. F. would be a quarter period behind the phase of the E. M. F.; thus the maximum current would occur when the nine fields were in the middle of the apertures of nine alternate armature coils, and the direction would tend to demagnetize the iron of the 2,000 volt machine and augment that of the 1,000 volt machine. Thus the fields are kept, one weaker and the other stronger, than before the armature circuits were connected, and as he believed, sufficiently so to equalize the respective electromotive forces. He closed by referring in terms of high commendation to Mr. Mordey's paper.

Mr. J. S. RAWORTH said that he had succeeded in measuring the lag between the dynamo and motor at full load, and found it to be exactly $\frac{18}{16}$ths of an inch, or 24° of a cycle.

Professor S. P. THOMPSON said that the load that would convert a generator into a converter need not be more than $\frac{1}{100}$th inch.

Mr. RAWORTH described some experiments not yet completed with a method which he had devised for measuring the actual E. M. F. of an alternating generator at any part of its period. He said that the curves were very astonishing and surprised everybody; the corollary was that it is not safe to prophecy until you are sure.

A communication was read from C. ZIPERNOWSKI in reply to certain statements made by Mr. Mordey, in which he stated that the alternate dynamos of his firm were satisfactorily running in parallel with loads varying from zero to maximum. He claimed that his establishment had been the first to make parallel coupling, an industrially proved fact. (See Mr. Blathy's letter in the *Electrician*, June, 1888.) They had not reduced the periodicity because of coupling in parallel, but had always maintained a rate of about 85 alternations.

A communication from Mr. G. C. FRICKER was read in which

the writer expressed his convictions as to the correctness of Mr. Mordey's deductions.

Mr. MORDEY in reply, said that he wished first to express his thanks for the kind reception of his paper. With all respect to Dr. Hopkinson, he said that he had derived no assistance from his theory, nor did he agree that that theory was sufficient to predict all the results obtained. He would not argue the point but would ask Dr. Hopkinson to kindly consider the matter again. The point where mathematical consideration of the subject appeared to him to have failed, was in not taking sufficient account of the stiffness of the field. Manifestly, with any impressed field, the controlling power of the machine would be quite inconsiderable, although the volts of self-induction and resistance relied upon by Dr. Hopkinson, would be the same as when working with a strong impressed field and under conditions of maximum generating and controlling power. Hence it was evident that a theory taking cognizance only of self-induction and resistance must be illusory. Continuing, he criticised Mr. Swinburne's statement in his recently published "Practical Electrical Measurement," that there were no alternate current motors; and referring to the induction coupler designed by Mr. Swinburne for the purpose of making such machines as those of the speaker run in parallel, he said that it was a very good illustration of the late theories. He had tried it without any improvement in the result, but the experiment had brought him to see that anything preventing the instantaneous passage of the correcting current must inevitably tend to prevent synchronism. He thought it was not at all clear that any of the advocates of Dr. Hopkinson's theory really understood it. It seemed to him to cover a multitude of quite opposite interpretations; it resembled the Hebrew prophecies in its comprehensive applicability to occurrences after the event. He was unable to follow Professor Adams in his analogies between alternations in parallel and tuning-forks vibrating in unison. He could see no analogy between rates of vibration and ratios of electrical pressure. The loud humming noise referred to by Professor Adams as evidence of self-induction when alternators were connected in parallel while out of phase, was really proof to the contrary.

He thought there was no real difference of opinion between Major Cardew and himself on the subject of safeguards. He, the speaker, recommended earthing as an absolute safeguard. It costs nothing and does not interfere with telegraph or telephone service. He did not admit that it increased the fire risk, on the contrary it lessened it by making it certain that a faulty transformer or house circuit cannot remain on, being instantly cut off by the safety fuse.

He considered Dr. Fleming's suggestion to account for the behavior of transformers with different periodicities as very ingenious, and was disposed to accept it.

Although strongly opposing some of Mr. Kapp's views, he highly appreciated his kind remarks. Mr. Kapp accepted all his facts but rejected his interpretations; he felt sure he would accept them both on further consideration.

Mr. Swinburne had placed himself in the honorable light of an interpreter of Dr. Hopkinson's mathematics, a position requiring great powers of endurance and considerable courage. He was prepared to find that Mr. Swinburne disagreed with most of his views. Mr. Swinburne had commenced with the very common mistake of supposing that, if there is practically no self-induction, there can be no generating or motive capability; the exact contrary was the case. The generating or controlling power depended almost entirely upon the field-strength and position relatively to the armature. The great object of the first section of his paper had been to show that views like those held by Mr. Swinburne were both practically and theoretically wrong, and he was surprised that a literal restatement of them had been put forward. Mr. Swinburne's conclusions on the efficiency and dimensions of transformers were interesting, but there were so many variable conditions and so little actual knowledge of the laws governing heating, that he thought it would be better for the present to rely mainly upon experiment. Mr. Swinburne felt sufficiently sure on this and all other points to rely upon his calculations for transformers working under widely different conditions. He admired his courage, but advised him to prepare for disappointments when the transformers were constructed.

In reply to Professor Silvanus Thompson and Professor Forbes, Mr. Mordey said the engines were not governed automatically, but by hand.

He trusted Professor Thompson would continue his very interesting experiments on the seat of counter E. M. F. in arcs. The subject required investigation, and the method used would probably yield useful results in comparing direct and alternate current arcs. He supposed it might be taken as proved that the arc has an E. M. F. as well as a resistance, and with a rapidly alternating current it seemed possible that this might produce a lag, acting something like electro-magnetic self-induction; such an effect might perhaps be found also in electrolysis. He agreed with Professor Forbes that it was wrong to suppose there were only two means of distributing alternate currents. Working parallel is often a great convenience, but in many cases it might be better to work singly.

He was sorry that Mr. Zipernowski should think the statement he had made about his alternators in parallel were erroneous, as the authority for the paragraph was his own letter published a few days previous in the "*Electrician*." He would leave the opposing statements to speak for themselves. He should look forward to seeing an actual description of the Ganz alternate current motor, the publications respecting which had been remarkable for the small amount of definite information which they contained, but for which there were no doubt good and sufficient reasons.

GLOBULAR LIGHTNING.[1]

THE following account of a display of globular lightning will, I think, be of interest to your readers, as it was well observed by several independent observers, and differs in some respects from those previously recorded. It is greatly to be wished that this phenomenon could have its place assigned to it in electrical theory.

On Monday, the 5th instant, at midday, this district was visited by a violent storm of rain, which lasted half an hour, and was accompanied by thunder and lightning. When the storm had passed over and the sky was getting bright, a rod-like object was seen to descend from the sky. It is described as being of a pale yellow color, like hot iron, and apparently about 15 inches long by 5 inches across. These dimensions are given by an observer who estimated its distance (about correctly, as it subsequently appeared) at 100 yards, and are not, therefore, affected by the uncertainty attaching to estimates of the sizes of objects whose distance is quite unknown. This object descended "moderately slowly," not too fast to be followed by the eye," and quite vertically.

On reaching a point about 40 feet from the ground, and in close proximity with a chimney stack belonging to a house in Twickenham Park, the object seemed to "flash out horizontally as if it burst," showing an intensely white light in the centre and a rosy red towards the outer parts. At the same instant a violent explosion was heard, and soon afterwards a strong smell was perceived, which is described by the observers as "resembling that of burning sulphur," for which the smell of ozone and nitric oxide might easily be mistaken.

Ordinary lightning is frequently most capricious in its action. In this respect this globular flash was in nowise behind.

I examined the outside of the chimney stack carefully, but no external effect whatever was visible. Inside, however, remarkable effects were produced, and I quote the following:—

"The back rooms consist of (1) basement kitchen; (2) ground floor dining-room; (3) first and second floor bed-rooms, and at the top a half attic. A stack of chimneys runs up the whole, and projects about six feet above the roof. There are no chimney-pots. No one was in any of the rooms except the kitchen, in which the servants were, and in which a fire was burning.

"The explosion filled the kitchen with smoke and soot. The dining-room also was filled with smoke and soot, though no fire was burning in it.

"The master of the house was just coming into the dining-room from the conservatory when he heard the detonation and simultaneously saw a bright flash of light. He staggered back a moment, and then ran through the smoke and soot to the hall, and called out to know if anyone was hurt. Finding all safe he returned into the dining-room. A Japanese umbrella set open as an ornament in the empty grate, but not fixed in any way, was undisturbed, though the hub of it was hot to the touch. Piles of soot spread out in a semicircle to the centres of the side walls of the room, and an arm-chair, which had been standing close to the fire-place, was six feet from its previous position, and had evidently been turned round and thrust against the wall. In the bed-room, on the first floor, soot was on the floor and in the fire-place. The slab of marble forming the architrave under the mantel-shelf, and extending the whole width of the fire-place, had been thrust out from its setting, and was, with a number of bricks, lying six feet away on the floor. The mantel-shelf and pier-glass were undisturbed. In the second-floor bed-room, soot and mortar were in the fire place and on the floor; one end of the grate was broken and a piece of the detached cast-iron (some three inches square) was lying against the wall six feet to the right. In the attic bed-room, mortar reduced to the condition of fine silver sand was lying in the fire-place and on the floor; the wash-stand, which stood against the fire-place, was pushed some two or three feet towards the centre of the room, but not overturned; and the carpet was rumpled up. There is in this room a bell on the wall opposite the fire-place, and a helical check-spring passes from this bell to an attachment in the wall. At this point of attachment a piece of plaster of the size of one's hand had been detached from the wall, and was found near the fire-place, 18 feet off at the other end of the room."

At this time, when electrical theory is receiving so much attention, the views of a theorist such as Dr. Lodge would, I think, be of great interest on the subject of these rare discharges. To all appearance a detached portion of something—is it atmo-

1. From Letters to the Editor.—*Nature.*

spheric, or ethereal?—is carried along bodily through the air, bearing with it a very considerable potential energy, and at the same time radiating light. At an instant determined, perhaps, by its proximity to the chimney stack, its constraint is suddenly relieved, and a discharge like ordinary lightning seems to occur between it and the earth, *via* (as it seems) the heated air of the chimney. Has anyone an explanation for this? A. T. HARE.

Neston Lodge, East Twickenham, August 24, 1889.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Mr. S. Oi, of the Ministry of Communications, Japan, Visits America; Interesting Notes of the Telegraph Service in Japan.—Serious Damage to Electric Lines Caused by the Recent Heavy Rains.—Lower Broadway Looks Better without Telegraph Poles.—The Weems Electro-Automatic Transportation System to be Tried at Garden City.—Newark Wants Electric Railways.—The "New York World" Booming Drawbaugh.—Beginning of the New Courses in Electrical Engineering at Columbia and Princeton.

MR. S. OI, of the Japanese government telegraph, is spending some time in this city, investigating American telegraph systems and shop practice. He gives many interesting particulars regarding electrical matters in his native country, and it will surprise many to learn that the Japanese Electrical Society, organized about two years ago, has now attained a membership of 1015. The Morse system, with 48 characters in the code, is used in Japan. The service is classified, the highest class of business taking precedence over even government messages. Double the ordinary rates are charged for this preferred service, which is almost universally patronized by members of the stock exchange and the rice trade; the latter being the most important branch of commerce. Mr. Oi has made a trip to Boston, for the purpose of investigating the practical working of electric railways in that city, their introduction in Japan being under consideration.

The recent rain storm of almost a week's duration, not only led to the usual number of accidents arising from the use of "undertakers' wire" in this city, but seriously interfered with telegraphic communication between the coast towns of Long Island and New Jersey, and this city. A large proportion of the wires were broken, and in many places considerable sections of the lines were entirely carried away by the fury of the ocean on the Jersey coast.

The removal of the poles and wires from the eastern side of Broadway below Fulton street, gives an improved appearance to the street, and enables one to see to Bowling Green from a considerable distance. A line of dilapidated electric light poles and wires still remain on the western side, and are likely to stay there until they tumble down. There were a good many telegraph men who were willing to admit, during the storm, that the service was better than it would have been had their wires remained on poles.

The Weems electro-automatic system of transportation, which has been making a sensation in the vicinity of Baltimore, is to be further developed at Garden City, L. I., where a circular track will be thoroughly equipped with 55 pound rails, and an opportunity offered to prove the possibility of running a light train over it at the rate of 5 miles per minute, which the inventor thinks possible. A suitable track for regular service can be constructed, it is stated, for $5,000 per mile. It is, perhaps, needless to add that nothing but a practical demonstration will satisfy skeptical engineers that the high speed mentioned can be attained and kept up. The fact that a plant of this kind is to be established, and that upon its success depends the future welfare of the concern, seems to indicate that there are people who have faith in it.

The citizens of Newark are now determined to secure a serviceable electric railway system. The city's growth has been retarded by its lack of rapid transit facilities, and the cable plant for which they have patiently waited for two years has proved an utter failure.

The Daft people are running a car experimentally, which has given satisfaction, but, of course, is no indication of what might be done with a fully equipped line.

The daily *World* has recently worked up a "fake" to the effect that the American Bell Telephone Co. has acquired a controlling interest in the Drawbaugh syndicate, for the purpose of using the alleged invention as a basis for extending its monopoly by permitting the issue of the Drawbaugh patents. The story is given as a rumor, but is worked up in so clever a manner as to seem a reasonable story to the uninitiated. The various conflicting "original telephone inventors" are said to have pooled their issues, and will renew the attempt to break down the Bell patent.

The new schools of electrical engineering at Princeton and Columbia colleges, give every indication of receiving encouragement through the entrance of students in considerable numbers at the opening of the term. The scientific class at Princeton is double that of last year.

PHILADELPHIA.

Underground Wire Contentions.—Proposed Addition of an Electric Plant to the City Gas Works.—The Electric Street Railway Syndicates; Contracts with the Thomson-Houston Co.—The Electric Railway Co. at Lebanon.—Other Street Railways.—Electric Lighting for the Cruiser "Philadelphia."—A Westinghouse Lighting Plant for Spreckel's Sugar Refinery.

DIRECTOR WAGNER stands firmly upon the ground he took sometime ago in refusing permission to electric light companies and other corporations to tear up newly paved streets for the purpose of laying conduits or other underground work. He says, the department has always given ample notice of the intention to lay new and improved pavements, and if parties have neglected to lay their conduits it was their own fault.

At present there is a prospect of a conflict between the director and the Edison Electric Light Co., lessee of the conduit of the Penn Electric Co. One bone of contention is the refusal to allow the paving to be torn up, but a more serious one occurred when warrants were issued for the arrest of the president and superintendent of the company, and the foreman who had charge of tunnelling under Cuthbert street, for the purpose of reaching the Masonic Temple from Arch street.

A provision of the Penn Electric ordinance is that all municipal buildings along the line of their conduits except City Hall shall be lighted free of charge. To reach the Masonic Temple without passing the head-quarters of the bureaus of gas and water, the company laid their wires through the cellar of the Arch Street Methodist Episcopal Church, and then tunnelled under Cuthbert street. Chief Bullock, of the highway bureau, dug down on Cuthbert street and cut the conduit, and warrants were sued out for the arrest of the officers.

The Inquirer's proposition of combining an electric plant with the city's magnificent gas works, so as to make the heat from the enormous consumption of coal do the double duty of making steam to run the city's dynamos, is a subject that will command the consideration of this session of councils.

This scheme has been experimented upon with success, and director of public works, Wagner, chief engineer Parks, of the gas works, and many others, said it could be done. How much the economy of coal would amount to when the combination of electric and gas plants is tried on such an extensive scale is only a matter of conjecture. The majority of engineers, the stokers and men familiar with the gas works say that the heat wasted by the consumption of coal in thousands of fiery retorts would make an incalculable amount of steam.

It has been said that the best results could be obtained by building the boilers in horizontally, side by side with the retorts of the gas benches. The rebuilding of some gas stacks every year would offer an opportunity to adopt this plan without interfering with the manufacture of gas. But boilers may, without material alteration of the stacks, be set up over them at a cost no greater than that of setting them up separately. Proof of this is furnished to any eye that has seen the flames pouring out the tops of the gas furnace stacks—flames that should be used by passing them through the flues of a steam boiler, as has been done for years in rolling mills.

The plan urged by *The Inquirer* is said by electricians to have been in the minds of the monopolists who made an effort to secure possession of the Philadelphia Gas Works a few years ago. The instant such a purchase could be made, it was their idea to double the value of their new property by making it furnish all electric lighting as well as gas for private and public use.

The cost of running an arc light, counting interest on capital and everything, averages, it is thought, only 18 cents a night. The city is charged an average of 50 cents, and private consumers in some cases, as high as 75 cents a night.

Mayor Fitler and General Wagner have said in their annual reports and in interviews, that there was no reason why the city, with a plant of its own, might not reap profits or at least save extravagant charges.

At the last session of councils, a special committee was appointed to consider the prospect of the establishment of an electric lighting plant.

Chief Walker, of the electrical bureau, has prepared estimates for the consideration of the Mayor. It has been supposed in the past that the plan was for a separate electric lighting station at the present Kensington pumping station or elsewhere. There is every reason to believe that a new and better plan will be presented, and that councils will not favor the Kensington location. The Kensington station is so far removed from the best lighting districts as to entail enormous expense for wiring. The central parts of the city are the best electric lighting districts, and where the most profitable stations of the private companies are located. The establishment of a plant at the Ninth Ward Gas Works would light Market and Chestnut and neighboring streets as conveniently as the present stations of the private companies.

George F. Work, representing one of the two syndicates recently organized in Philadelphia for the purchase of passenger railways in other cities, recently signed contracts with the

Thomson-Houston Electric Co., for the equipment of two roads that have been bought.

The method of procedure of Mr. Work's syndicate, which is already incorporated, is first to purchase a road that has been doing an unprofitable or poor business, at a cash price, which will be considerably below par, and equip it as an electric road, which can be run much cheaper and faster than horse cars. The syndicate estimates a saving of 25 per cent. in running expenses, and an improvement of the same amount in the receipts, by reason of the novelty and better service rendered by the electric cars.

A second syndicate was formed for the same purpose a short time ago. As soon as possible this syndicate will obtain a charter under the laws of the state of New Jersey and begin operations. The intention is to use the Thomson-Houston system of overhead wires on the roads purchased. The new syndicate will not confine its field of operations to any particular section of the country.

At Lebanon, Pa., the Lebanon Electric Street Railway Co. is awaiting a reply from the Berks & Dauphin Turnpike Co. before they begin the construction of their roadway through the streets of the city.

The Turnpike company is under bonds to keep Cumberland street, the main thoroughfare of the city, in repairs, for their pike extends through the city from the eastern to the western limits. The electric railway people are negotiating with the company for a right of way, but the Turnpike men are not willing to grant it. They want the Street Railway Co. to appropriate the street by their rights of occupancy under their charter, and then pay the Turnpike company damages, and enter bonds for keeping Cumberland street in good condition. No settlement has yet been made, and it is doubtful whether one will be reached unless the railway men take possession of the street and pay the damages.

Mayor Barrows, the board of alderman, and thirty-two other prominent residents of Utica, N. Y., visited Scranton, Pa., recently, to inspect that city's electric railway system. This was done on account of the petition of the Utica Belt Line Co. for permission to use electricity for propelling its cars.

Camden is to have an electric railway running from Market street ferry to East Camden and ultimately to Merchantville. Vice-President E. N. Cohn has obtained from the highway committee of city councils permission to erect the necessary poles, and an ordinance was recommended to the council to grant the privilege. Mr. Cohn said wires would be strung on the telephone and telegraph poles now standing wherever possible.

The stockholders of the Citizens' Passenger Railway, of Norristown, Pa., are contemplating the sale of the road to the New York Improvement Co. It is the intention of the New York parties, should they acquire possession, to substitute electricity for horses as motive power.

The new steel cruiser *Philadelphia*, recently launched from Cramp's ship yard, will have two electric light plants of the most approved pattern, and the most compact system adapted to marine work. Each of the dynamos is to be capable of producing 3,200 candle-power of light, and lights of 10, 16, 32, and 50 candle are to be used on the same circuit, with an independent control over each lamp. All parts of the vessel will be fully lighted by incandescent lamps, including the coal-bunkers, magazines, shell rooms, ammunition rooms, running lights, and lights for use on the upper decks and aloft.

Mr. Claus Spreckels has awarded the contract to light his immense Philadelphia Sugar Refinery to M. R. Muckle, Jr. & Co., of Philadelphia. At present 2,500 incandescent lamps will be installed. The Westinghouse alternating system will be used.

PHILADELPHIA, September 16, 1889.

BOSTON.

The Increase of Capital Stock by the Bell Telephone Co.—The Government Telephone Suit.—The Police Patrol-Wagon System of Boston to be Examined by Captain Douglas of the San Francisco Police.—New Electric Lighting Companies.—The West End Railway Co.; its Increase of Capital; Energetic Work in Extending its Electric System; its Trial of the Plan of Stated Stops Only on the Cambridge Line.—Increase of Fire Losses from Electric Wires in Boston.

A SPECIAL meeting of the stockholders of the American Bell Telephone Co. was held on the 12th inst. In respect to the act of the Massachusetts legislature authorizing the company to increase its capital stock from $10,000,000 to $20,000,000, the president stated that the directors thought it would be sufficient to increase the capital stock by $2,500,000, as this would meet all requirements until the annual meeting in 1891.

The following action was taken :—

Voted, that the amount of the capital stock of this company be, and the same is, hereby increased from $10,000,000 to $12,500,000, and the number of shares therein from 100,000 to 125,000, each of the par value of $100, and

Voted, that the directors do give notice in the manner prescribed by law to the stockholders of record this day of such increase and of their right to take shares at par therein in the proportion of one new share to four old shares held by them respectively, such shares to be paid for in cash and issued at such times as the directors may determine ; and that all shares not so taken be sold or issued by the directors for cash at not less than par in such manner as they shall determine.

The president said that the directors propose to issue $1,250,000 payable October 20, 1889, and $1,250,000 payable April 20, 1890. The rights will attach to stock of September 12, the date of the meeting, and will expire October 15. The rights, on the basis of the present price, will be worth about $27 or $28. Four rights, at $28, would be $112 ; add to this $100, the subscription price, total cost per share of the new stock $212. This figure, $212, it is thought will certainly look cheap for a stock paying $18 per annum in dividends and, with more "plums" in prospect from the remainder of the increased issue of stock, when it shall come out. But as a matter of fact the rights opened at $25 each, and sold off to $23, which makes a better purchase.

In the United States Circuit Court, on the 9th inst., in the case of the United States of America *vs.* the American Bell Telephone Co., Judge Colt gave a decision authorizing the defendant company to withdraw its answer, and to file the same plea and answer in support thereof which has been filed by Bell. Judge Colt says :—"While it must be admitted that a motion to withdraw an answer and substitute a plea is rare in equity cases, still, taking into consideration all the circumstances as presented in this case, I am of the opinion that the justice and convenience of the case will best be promoted by having the issues proceed *pari passu* as to each defendant."

Early on the morning of the 11th inst., at New Haven, Conn., fire was discovered on the fourth floor and roof of the Yale Bank building, where a network of electric light, electric clock, telephone and postal telegraph wires enter the cupola. The top floor was gutted, and the business offices on the three lower stories flooded with water. The heaviest losers are the Southern New England Telephone Co. and Postal Telegraph Co., whose wires were burned off, causing great confusion and delay in the handling of business. The fire is supposed to have been caused by an electric light wire which became crossed during the gale.

The police commissioners of San Francisco, having determined to introduce the patrol-wagon system into their service, have appointed Captain Douglass to visit Boston and other cities in the east to examine their patrol systems. The captain, who is now on the way, has been on the force of San Francisco for more than 30 years, and is a keenly observant man. His main object will be to see which of the various systems is best suited to the peculiarities and topography of San Francisco.

The chief of police of San Francisco has collected statistics of the number of policemen required to the square mile patrolled in the principal cities, and the following table, compiled from statistics in his possession, is of considerable interest :—

	Square miles patrolled.	Number of policemen.	Number per square mile.
New York	41½	3,500	85
Baltimore	14½	705	50
*Chicago	37	1,145	31
Boston	37	790	21
Cincinnati	21	414	18
Cleveland	31½	334	11
San Francisco	41¾	400	10
St. Louis	62½	555	9
New Orleans	65	308	5

*Chicago's force is now somewhat larger.

Three new electric light companies have been incorporated respectively in Mansfield, Braintree and Foxborough. William A. Stiles is president, and Henry N. Bates, and these, with Melville P. Morrell, constitute a majority of the board of directors. These companies are supposed to be factors in behalf of the Westinghouse in the contest which is going on between that company and the Thomson-Houston people.

The directors of the West End Street Railway Co., on the 12th inst., voted to issue the $4,000,000 (80,000 shares) of common stock recently authorized, probably in blocks of $500,000, as the money may be needed, although this is not settled definitely. The stock must be issued at par to present common stockholders, that is to the West End Land Co. It is for the officials of the last named to decide as to methods of taking it, whether collectively as a company or individually through its stockholders. The inference is that West End Land stockholders will be given a subscription right, but no definite progress appears to have been made with this matter as yet, but a plan is likely to be adopted at the meeting of West End Land trustees this week, possibly to-day.

Everything possible is to be done by the West End Railway to hasten the extension of its electric line to Franklin Park. New construction is made necessary by the adoption of what is known as the Johnson girder rail, and it is intended that the track shall be smoother and better than any now in use in the city. On Washington and Warren streets at Roxbury, the work of rebuilding the track will be carried on in sections. About 10 miles of track will be rebuilt at once, and only the desire to put the electric line in operation as soon as possible would induce the management to attempt this bold undertaking so late in the season. It is impossible to say when the contemplated work will be finished, but the contract calls for its completion on or before November 20. General Manager Monks says that the electric wires will

certainly be in place by that time, and there is no doubt that the machinery at the new power house—formerly the Hinkley Locomotive Works—will then be ready for operation. The track on Tremont street will not be relaid at present, but the electric cars will run as far as Haymarket square, returning by a loop line.

In the spring the electric line will be established at South Boston, and will be extended in other directions as fast as practicable.

The old buildings at Grove Hall, including the car house, shops and stables, occupying a total area of about 78,000 feet of land, are to be sold at once and moved away. Upon the site thus cleared is to be erected a new car stable, which is to be the largest in New England. It will have space for 225 cars, and will be made the central stable of that section. It is said, also, that a new stable and power station will be erected on land bought at the corner of Washington and Glen Road streets opposite Green street at Jamaica Plain.

The stockholders of the Newton Electric Railway have decided to begin immediately the work of constructing the proposed loop road, running through Newton, Watertown and Waltham, as rapidly as possible.

The Cambridge people have complained that the electric cars do not stop often enough—there being but four stoppages per mile. Upon inquiry at the offices of the West End Railway, it was learned that the manager has received numerous letters of complaint as to the inconvenience of the new system and method of running. One complainant wanted one of the stops relocated, but did not want the number increased; another wanted a station 100 feet distant from the one now in use, but no increase in the number of stoppages; and so on *ad infinitum.* These communications have all been heeded, if not answered, and the officials are willing to receive and read all that come to them with suggestions, as they are desirous of serving the public thoroughly. "But," said manager Monks, "our decision as to stopping places was made after every deliberation and frequent trips of the directors, individually and collectively, over the line, and the plan as determined upon will serve by far the larger majority of our patrons. To our idea, the present running time is a success. We are running 15-minute cars to Arlington on week days and 10-minute cars on Sundays, whereas on the horse system they were run half-hourly. If more frequent stops are to be insisted upon by the majority of travelers, it will be only at the expense of rapid transit. We claim making long distances quicker than elevated railways, as by the electric system we can stop and start quicker than by steam, thus saving time."

From the annual report of fire marshal Charles W. Whitcomb, it appears that the amount of loss caused by accidental fires is placed at 47 per cent. of the total fire waste of the year, as against 31 per cent. last year; and this increase is mainly due to fires arising from spontaneous combustion, on account of which the percentage of loss is increased from 9 per cent. last year to 34 per cent. this year, and to fires caused by electric wires, the number of which has increased three-fold over last year.

BOSTON, September 16, 1889.

CHICAGO.

The Fire in the Exposition Building.—Convention of the Fire Underwriters of the Northwest at Chicago.—Discussion of Electric Risks.—Views Upon the Failure of the Telephone Association to Act Upon the Question of the Duty on Copper.—Chicago Still at Work to Secure the World's Fair of 1892.—The Four New City Electric Lighting Stations.—An Electric Railway Company.—Extension of the Edison Underground System.—The Lighting of the Auditorium Building.—Marriage of Mr. Charles H. Wilson.—Extension of Long-Distance Telephony.

IT is seldom that it becomes the duty of the Chicago correspondent to make mention of fires due to electric lights. Chicago has been free in a marked degree from fires caused in this way. On September 14th the exception occurred. The exposition is now in full blast. The building will be well remembered by those who attended the February convention of the Electric Light Association, for the meetings of that body were held there. About 10 o'clock, while several thousand persons were in the building, a fire broke out. It is thought that a portion of a carbon of an arc lamp fell into a pile of gauzy material in a dry goods booth. In a moment a flame burst out and set fire to adjoining booths. The cry of fire was raised and in an instant a panic seized the persons in the building as they saw the clouds of smoke rolling toward them. A rush was made for the doors and several persons were injured. Meanwhile the firemen went to work with a will, and in a short time the fire was under control. About $100,000 worth of property was destroyed. The fire was investigated by City Inspector Haskins. It is his opinion that the fire was caused in the manner spoken of. As far as can be discovered there was nothing the matter with the lamp, and it is the general opinion that the fire was due to one of those accidents which can hardly be foreseen or guarded against.

The Fire Underwriters' Association of the Northwest held its annual convention in Chicago, September 17th and 18th. Among the papers presented was one by C. C. Haskins, city inspector of electric lighting in Chicago. His subject was "Electric Lighting; Its Hazards and How to Guard Against Them." He said the fact that electric lights were the cause of a considerable number of fires constituted the best evidence that greater precaution should be observed in the use of wires. He thought that underwriters' associations should have inspectors to see that proper safeguards were used in every installation. He thought no alterations should be allowed in a plant without proper notification. This was recommended as absolutely essential as a measure of precaution. Mr. Haskins said a point of danger was to be found in the practice, especially in smaller towns, of using improper places for the head-quarters of an electric light plant. This oversight means a perpetual danger to life and property. As a practical inducement to the electric light people to do their work properly, Mr. Haskins urged that insurance companies address themselves to the electric companies by offering inducements in the event of a proof of lower risk, while on the other hand a carelessly erected plant should be held as entailing a higher rate against buildings wired by the careless company. Such a method would insure proper work. In concluding Mr. Haskins said:—"The underwriter may help materially by refusing to write up a risk without some surety that the wires are in proper condition; by notifying the inspector when alterations are made in buildings, whether by carpenters, plumbers, or otherwise. The most perfect plant may be ruined by a common helper without half trying or even knowing what he has done. These innocents have their place in the economy of the world, but, as a rule, they make inferior electricians."

"In respect to the failure of the Telephone Association to act upon the question of the duty on copper I was surprised," said a gentleman who was present at the convention, "because it seems to me that the removal of the duty would be for the advantage of every telephone company in the country. Of course, several of the gentlemen who represented districts in which the protection sentiment is very pronounced might naturally oppose a measure which possessed a free trade appearacce, but I hardly think this objection could be made to the copper resolutions. There is no earthly reason for the protection of copper. Then, too, a man ought to protect his own business. Unquestionably the removal of the duty would tend to increase the profits of telephone companies, and telephone subscribers, whether of free trade or protection tendencies, could scarcely be silly enough to think that the owners of a given exchange should shape their views on a business matter solely in accordance with the ideas of their subscribers and not in accordance with their own best judgment. Subscribers would scarcely give up their instruments because telephone companies favored a measure of this kind. The idea is absurd. I hope to see the duty on copper removed, and I expect to see it removed. I am sorry that the Telephone Association did not give those who have the matter in charge its cordial assistance."

It is impossible to look at any department in a Chicago paper without seeing a reference to the World's Fair. It may appear an astounding statement, but true it is, that the great majority of Chicagoans actually believe that the prize is coming west. A meeting of the representatives of the electrical interests of Chicago met recently at the rooms of the Chicago Electric Club. B. E. Sunny, of the Thomson-Houston company, chairman of the committee appointed by Mayor Cregier, outlined the plans for raising funds for the exposition. A resolution was adopted endorsing the project for holding the exposition in Chicago. Considerable interest was shown in the scheme by the members of the local electrical fraternity. The following committees were appointed:—

Central Station Lighting Companies—C. H. Wilmerding, F. S. Gorton, D. P. Perry, C. C. Haskins.
Wire Manufacturers—Fred. E. Degenhardt, George Cutter, G. B. Bailey.
Incandescent Apparatus Manufacturers—E. M. Izard, G. O. Fairbanks, C. C. Warren.
Arc Apparatus Manufacturers—Alex. Kempt, F. W. Horne, John L. Martin.
Telephone Companies—F. G. Beach, Henry B. Payne, Flemon Drake.
Miscellaneous Electrical Manufacturers—M. A. Knapp, E. A. Sperry, Foree Bain.
Motor Manufacturers—T. P. Bailey, C. M. Barclay, A. H. Lewis.
Merchandizing Companies—F. S. Terry, W. H. McKinlock, C. D. Crandall.
Electrical Journals—W. A. Kreidler, Fred. De Land, C. C. Haskins.
Legal Committee—William Zimmerman, E. C. Ferguson, F. W. Parker.

The committee subsequently sent to the sub-committees a circular letter, of which the following is an abstract:—

> The representatives of the committee appointed by the Mayor, will be ready at all times to direct and assist in the work, and ask that they be called upon whenever they can actively assist. While the large corporations can be depended upon to contribute generously to this great undertaking, we must be sure not to overlook the employés, who, no doubt in every instance desire to be identified, if only to the extent of one share, with this magnificent enterprise.

The employés of the Western Electric Co. have already organized to aid in the work of bringing the fair to Chicago.

The four new city electric light stations are to be built on the same general plan. In all the stations the dynamo rooms will be located on the second story, directly over the engine room on the ground floor. The engines will belt direct to the generators.

The boilers will be of ⅜ inch steel, and of the horizontal tubular type. Pipe connections will be made so that one boiler may be used independently, or any number may be used in common. The boilers will be 18 feet long by 62 inches diameter, and each one will have 55 4-inch tubes. The settings will be of brick. All the boilers will be built to carry a regular pressure of 100 pounds, and be tested to 150 pounds. Two independent feed pumps in each station will supply the boilers. The engines will be of the horizontal automatic type, each one of 150 h. p. They will run at 230 revolutions per minute, with a steam pressure of 100 pounds. Each engine will have two double belt driving pulleys of 68 inches diameter and 22 inches face. By this arrangement of double belt pulleys each engine drives, if desired, four dynamos. All the engines in a station exhaust into a heater and purifier. The electrical apparatus has not yet been decided upon. For three of the stations Ide & Sons, of Springfield, have obtained the contracts for entire steam plants. Professor Barrett considers that the steam equipment of these stations will be temporary. He proposes eventually to replace the high speed engines in each station by two large compound engines, one of which will be able to take the entire load. The other will be held as a reserve. The smaller engines will then be removed to such outlying districts as will be supplied with electric lights.

Benton Halley, A. J. Toolen and J. H. Ludden are the incorporators of a company which proposes to install an electrical railway in Chicago. They will not attempt to use an underground system, but will operate a road, if at all, in some part of the city where overhead wires are not forbidden.

The underground system of the Chicago Edison company is being considerably extended. Extensions are being made on State street, Randolph street, Madison street and Dearborn street. The central station plant is to be increased by four 1,250 light dynamos and a 200 h. p. Ide engine.

There will be 10,500 incandescent lights in the Auditorium building. The original contract called for 8,600, but an additional 1,900 were found to be necessary. The work and the plant has been substantially completed.

Charles H. Wilson, superintendent of the Chicago Telephone Co., and Miss Phoebe Hollister were married in St. Louis, at the residence of the bride's parents, September 18th.

Chicago, Milwaukee and Hammond, Ind., are now connected by the wires of the American Telephone and Telegraph Co. The service is giving great satisfaction. Stations will be established along the line as rapidly as business will warrant.

CHICAGO, Sept. 23, 1889.

ST. LOUIS.

Growth of Electrical Enterprises.—The Municipal Electric Light and Power Co.—Electric Street Railway Notes.—The Westinghouse Plant of the Missouri Electric Light and Power Co.—Electrical Exhibits at the St. Louis Exposition.—Important Displays by Leading Companies.—A Notable Collection of Electric Lighting Outfits.

ELECTRICAL industries are making rapid headway in St. Louis during the present year. The entire city is to be lighted by arc and incandescent lights after January 1st, 1890. A subway company, using the Dorsett system has been incorporated, and have laid an 18-duct subway on Broadway, from Locust to Elm, and also from 14th street to Broadway, part of which is on Chestnut street, and part on Market street. They intend to cover all necessary parts of the business centre of the city.

The St. Louis Bridge Co. have about finished relaying their roadway and have begun erecting the overhead wires.

The Municipal Electric Light and Power Co., who have the contract for lighting the city with arc lights after January 1st, 1890, are making rapid headway with their plant. The company experienced some delay in securing a suitable location for their station, but finally made a very good selection on the Missouri, Pacific Railway, just west of 18th street bridge, where they have advantages of cheap transportation of coal. Much difficulty and delay was also occasioned in getting foundations for walls and machinery. The location happened to be an old stone quarry that had been filled up. Some 1,800 piles were driven, and on top of this was laid 20 inches of timber, and on top of this a course of concrete three feet thick. This part of the sub-structure covers the entire area of the buildings, and on this the basement walls and foundations for the Corliss engines was laid.

The boiler house will be a substantial fire-proof brick building, 1½ stories high, 60 by 150 feet, with stack 200 feet high. Twenty 250 h. p. upright boilers from Rhoan Bros., St. Louis, with their patent filters and feed water heaters and a new mechanical stoker will supply steam. Coal will be delivered from the cars by gravity onto bunkers six feet above the grade bars.

The main building, 100 by 110, four stories high, fire-proof throughout, will be used as follows:—On the first floor will be located eight Hamilton Corliss engines, 28 x 60, and two Buckeye high speed engines, 14½ x 16. The second floor will be used for shafting, pulleys and clutches, of which there will be four lines of six inch shafting, each 100 feet long, with 56 double crown friction clutch pulleys, by the Falls River Machine Co. The third floor will be used as the dynamo room, in which will be located 120 35-light dynamos from the Indianapolis Jenney company.

The belting will be supplied by three different firms, viz.:—Chas. A. Schieren & Co., New York; Munson Belting Co., Chicago; and the Schultz Belting Co., of St. Louis.

The fourth floor will be used as a store supply and repair room.

A small station for commercial lighting is being fitted up near by, at 17th and Austin (also on line of the Missouri Pacific Railway Co.). This installation will consist of two Buckeye 60 h. p. engines, four boilers, each of 100 h. p. capacity, and eight Jenney dynamos of 35-light capacity each.

Their contract with the city calls for 1,590 arc lamps of 2,000 c. p. on January 1st, 1890, and runs 10 years. The number will be increased to probably 2,300 by March 1st.

About 150 miles of pole line with 400 miles of wire will be used. In construction, 40 poles to the mile will be used, and the entire length protected by a lightning wire composed of No. 8 iron wire connected to earth at every lamp pole. Simplex wire will be used. Circuits will average 18 miles in length.

In the down-town district the ducts of the St. Louis Subway Co. will be used. The company claim that they will have the largest arc light station in America, if not in the world.

The St. Louis Railroad Co., after a severe trial of the Short series system on the south end of their road have determined to reconstruct the entire section in a substantial manner. Johnson rails will be laid over the entire length of the section; the overhead wires will be supported by a new set of steel poles six inches at base and having wooden plugs and iron caps at top.

During the previous series of experimental operations a new form of switch was developed which the company feel satisfied will settle the question of switches for all time. The power house will contain when reconstructed a 150 and a 125 h. p. boiler, one 300 h. p. Wheelock automatic engine, and a 125 h. p. Payne engine, three 100 h. p. Brush generators of improved pattern. The rolling stock will be increased to 15 motor cars equipped with improved Brush motors operated from either end of car. The cars are manufactured by the St. Louis Car Co., each car having two motors of 15 h. p. each.

The Lindell Railway Co. have about finished their extension from the stables on Chouteau avenue, near Jefferson avenue, westward to Grand avenue. The power house is located on Compton avenue, on line of Missouri, Pacific Railway Co., from which they will get their coal supply over a short switch. The power house contains two Jas. Wangler's (St. Louis) 100 h. p. boilers, two Russell (Massillon, Ohio) engines of 150 h. p. each, mounted on concrete foundations, two Edison 107 h. p. dynamos, 400 volts and 200 amperes.

There is spare room for 700 h. p. addition to the plant. The rolling stock consists of six motor cars for the Chouteau avenue extension, and eight motor cars for the Vandeventer avenue extension which is now under construction. The Sprague overhead system is used, and has been constructed in a very substantial manner under the direction of Mr. W. D. McQuesten, of the Sprague company. Two circuits will be used for the Vandeventer extension, which is located about three-quarters of a mile from the power house, while the Chouteau avenue extension being close to the power house will only require one circuit.

The Missouri Electric Light and Power Co., Westinghouse system, who have the contract for the lighting of city buildings, parks and alleys, south of Washington avenue, after January 1st, 1890, have finished their station and are doing a large amount of business in commercial lighting. They will have a capacity of 50,000 lights; 15,000 now in operation, including the Lindell Hotel, Hurst's Hotel, Turner Building, Faust's restaurant, four theatres, and about 50 private houses, and other miscellaneous users. Meters are used in all cases. This company was organized and had the plans and buildings well under way before the city contracts were awarded, and have pushed everything with the vigor that is characteristic of the Westinghouse interests.

The station is a twin building, each portion being 116 by 68, constructed of St. Louis pressed brick, one story high, iron roof and fireproof throughout. In the boiler room are located two batteries of Babcock & Wilcox boilers, each battery of 550 h. p., fitted with Poney automatic stoker, Harrison elevator and conveyer, two Standard Westinghouse engines, each of 250 h. p., and two Duplex-compound Westinghouse engines, each 300 h. p., four 3,000-light Westinghouse dynamos and one 750-light. There are 35 miles of pole line, carrying 16 circuits each, having a capacity of 1,300 lights.

The electrical exhibit at the exposition building, is now nearly complete. Many exhibits were delayed in transportation and in other unexplainable ways. The Indianapolis Jenney and the Brill electric car exhibit has just arrived.

Noticeable, for finished and artistic display, we have the Excelsior Electric Co.—Hochhausen system—of New York. A 25-light automatic dynamo, drives two motors of 10 and 7½ h. p. respectively. The 10 h. p. motor drives a 100-light dynamo which supplies 75 lights and two small motors of one and three h. p. respectively. The 7½ h. p. motor drives a 5-light arc dynamo which supplies the arc lights of the display.

The Loomis Electric Manufacturing Co. exhibit a 300-light automatic dynamo driven by a Rice engine and lighting a waterfall and fountain and other parts of the building. They also show a complete display of accessories for their system, such as ammeters, voltmeters, lamps, sockets and fixtures.

The Ball Electric Light Co. have a 25 800-light c. p. dynamo which attracts much attention on account of its small size and excellent light.

The Heisler Electric Light Co. have two new 300-light alternating dynamos with automatic regulators, replacing two 200-light dynamos of last season, and lighting the art galleries, with a new pattern of reflecting hood, which gives an effect on the pictures like sunlight.

The Western Electric Co. have a high tension 35-light dynamo and a 150-light incandescent dynamo of the Badt pattern. In a separate division they have a general display of their miscellaneous merchandise.

The Westinghouse Electric Co. exhibit a complete outfit for central station working. An alternating dynamo of 750-light capacity, lights various parts of the building and a special display illustrating their manner of theater lighting, for which purpose they use a regulating rheostat. The display includes a small Tesla motor of one-sixth h. p., a Schallenberger meter, converters, lamps and fixtures.

The Thomson Welding Co. have a full set of welding apparatus which embraces an alternating self-exciting generator, a large two inch pipe welder also a welder for solid bars and a small machine for welding copper wire. Their exhibit proves to be the most interesting of any in the entire electric exhibition.

The Kester Electric Co., of Terre Haute, Ind., exhibit dynamos and motors of the four pole type, with drum armature and special winding in quadrants.

The Jeffrey Manufacturing Co., of Columbus, Ohio, exhibit their coal mining machine of 15 h. p, taking current at 220 volts and 50 amperes. The company also manufacture motor cars for mining purposes and undertake the lighting of mines.

The Sprague Electric Railway and Motor Co. have an electric street car, but not yet in operation, owing to some trouble in getting the proper voltage from the electric light dynamos.

The Burton Electric Co. exhibit the Burton heater for heating electric cars and other similar requirements. A model of a street car is heated by this device to illustrate the manner of application. Six small heaters placed under the seats gives out the necessary heat. Water is boiled by means of the heater. The heaters take a current of four amperes at 220 volts pressure.

The Cole Conduit Co., of Detroit, Mich., show their wooden conduit for underground service.

Parrish Bros. & Peck, of Detroit, exhibit their electric signal for freight and passenger trains. The device is intended to take the place of the bell cord, and appears to be well worked out. They also show electric signals for steamboats and steamships.

The Microphone Battery Co. exhibit a full line of microphone batteries, carbons and other fixtures.

Parker, Russell & Co., of St. Louis, have a large display of battery and arc light carbons, also fire clay merchandise such as fire brick, gas retorts and porous brick.

The Fidelity Carbon Co., of St. Louis, exhibit a large and artistically arranged collection of their goods—carbon battery plates and rods.

The Solar Carbon Co., of Pittsburgh, Pa., have a similar display.

The Butler Hard Rubber Co., of New York, display hard rubber in plates and rods both in the rough and finished.

The Central Electric Construction Co., of St. Louis, make a pleasing display of electroliers, incandescent lamps and fixtures and general electrical merchandise.

The Edison Phonograph and the Bell Graphophone are exhibited together in the electrical department and also in the entertainment hall.

The permanent plant of the exposition building consists of six Edison isolated dynamos, lighting the music hall and entertainment hall and all parts of the building except the art galleries, which are lighted by the Heisler company, under yearly contracts. The arc lighting is done by four Western Electric dynamos.

The American Leather Link Belt Co. and Chas. A. Schieren & Co. exhibit their respective well-known qualities of leather belting.

ST. LOUIS, September 22, 1889.

PITTSBURGH.

Contract for Public Lighting in Allegheny City.—Stoppage of the Knoxville and St. Clair Electric Railway.—Other Street Railway Notes.—The Equitable Electric Railway Construction Co. Organized.—The Western Pennsylvania Exposition.

THE councils of Allegheny City held a meeting last evening and awarded the contract for lighting the city of Allegheny by electricity to the Westinghouse Electric Co.

There were a number of bidders for this plant, and the spirit of competition manifested by the various companies was very keen. The city officials advertised for bids to make an arrangement on two different plans. The first was to rent light, and the other to sell the plant outright. The Allegheny County Light Co. and the Brilliant Electric Light Co.—formed by the representatives of the Fort Wayne Jenney Co. in this city—bid for the rental arrangement. The Westinghouse Electric Co., the Brush Electric Co., the Fort Wayne Jenney and the Indianapolis Jenney companies put in bids for the sale of a plant. As soon as the special committee of councils, which had been appointed to investigate the bids, had looked into the matter they at once decided against the rental arrangement, and all the bids on that score were thrown out. Then the bids for the sale of the plant were examined. The Westinghouse Electric Co., entered a bid for $141,000, the Brush Electric Co. $159,000, and the Fort Wayne Jenney Co. $140,000. After a few meetings of the special committee the contract was at last awarded to the Westinghouse Electric Co. The members of the committee decided that, in spite of the fact that the Westinghouse bid was not the lowest, the details of their offer were superior and more advantageous than those of the Fort Wayne Jenney Co.'s bid.

The plant will be erected on the corner of Marion street and Martin avenue. It will be fitted up with six Westinghouse compound engines. It will have a capacity of 450 arc lights and 3,000 incandescent lamps. A number of the arc lights will be placed on single pedestal towers of six lights each. The Westinghouse Electric Co. will erect and run the plant for six months, when the city will buy it outright.

The Knoxville and St. Clair Electric Railway Co., of this city, has suspended active operations for several months, and the stockholders of the concern are very anxious to know the reason why. The company built the road a little over a year ago. It is about four miles long and runs nearly all the distance up hill, and there are several sharp curves in the road. This appears to have been the greatest difficulty for the motors. The cars have had much difficulty in making their trips without a hitch of some kind.

The capital stock of the company is $65,000. An attempt was made some time ago to increase that amount to $135,000, but this failed, and the road is now in the hands of a receiver. What will be done next is hard telling; but in the meantime the motors are idle, the cars are shut up and the rails are growing rusty.

Last Tuesday morning a very exciting accident occurred on the Observatory Hill electric road in Allegheny, which might have resulted in serious loss of life; but fortunately one man only was slightly injured. The car was running down a steep hill at the head of Federal street, when the conductor lost control over his car. The brake refused to work and the car ran down the hill at an enormous speed. It was crowded with passengers, and had it not been for the presence of mind of a passenger a serious accident would have resulted. The ladies in the car were panic-stricken and were about to jump from the car but were restrained and quieted by a cool-headed gentleman. The car was at last brought to a stop by running off the track into the park.

The Equitable Electric Railway Construction Co., of this city, has applied for a charter. Messrs. William Stern, Isaac H. Silverman, Philip Silverman, G. D. Levy, A. H. Chadbourne, William Hazelton and W. A. Stadelman—the three last named of Philadelphia—are the incorporators. Messrs. Stern and Silverman are the agents of the Edison Electric Light Co. in this city, and they also represent the Sprague Electric Railway and Motor Co. The company has a capital stock of $50,000, and its managers intend to construct all kinds of electric railroads and equip them with any electric street car system desired.

The Western Pennsylvania Exposition Society has at last completed its buildings, and a few days ago the exposition was opened with great *eclat*. Of electrical exhibits there is not much to be seen at the exposition. A half-dozen phonographs, of the Western Pennsylvania Phonograph Society, are shown.

PITTSBURGH, September 20, 1889.

NEWS AND NOTES.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF SEPTEMBER 10, 1889.

The thirty-seventh meeting of the Institute was held at the house of the American Society of Civil Engineers, 127 East 23d street, New York, on Tuesday, September 10th, 1889. The meeting was called to order at 8 P. M., by Mr. T. Commerford Martin, vice-president, who introduced Lieutenant F. Jarvis Patten.

Lieutenant Patten then read his paper on "Alternating Motors: the Evolution of a New Type." (See page 424.) Having finished the reading of the paper, the author said :—

I might add that the inner commutator, the one which is the ordinary commutator of the Gramme ring winding does not perform the ordinary functions, as the brushes bearing on this collector require no adjustment, it being merely a rubbing contact from which the shunt field circuit is taken as a derivation from

the main circuit of the machine. With that exception I think the machine is fully explained in the paper.

DISCUSSION.

Mr. C. O. Mailloux—I would like to ask whether sparking occurs to an injurious extent or not?

Lieutenant Patten—The sparking being due to the electromotive force at the point of breaking, it will necessarily occur during the starting of such a machine and more than ordinarily when it is out of synchronism with the alternating current. At the outset, it can be easily seen that the alternating current is liable to be broken at a point where this electromotive force is high, and therefore the sparking would be very violent. I have endeavored to obviate the trouble due to that cause, in the machine—the device is shown in figure 5. If you will notice the circuits carefully it will be seen that the circuit of the alternating current is never broken. If the brush comes on to one of the dead segments or shaded segments connected with the rheostat before the alternating wave has come to zero, it finds a path which is at first in parallel with the machine circuits and then becomes a separate path for the alternating current during its change, whether this change begins at a high or at a low electromotive force. Of course, as the machine starts, this may happen at any period of the wave and the brushes passing over these segments connect with the resistance at the end of the group, and before it has left the group the current is already short-circuited through this rheostat. So that the alternating current always has a path and the sparking will not be excessive.

Mr. R. S. Dobbie—I would like to inquire whether the field magnets are laminated, and whether the lamination would be necessary only while the machine was starting up as an alternating motor or before the synchronism is attained. If the maximum torque of a machine is at one-third speed, what is the torque of the same machine at full speed when the synchronism is attained.

Lieutenant Patten—In answer to the first question, I would say, that there is no good reason for laminating the field magnets for any other purpose; but it has been shown by experiments that a laminated machine has a very definite neutral line of field, which makes it simpler and better for taking the direct current shunt for the field from that point without having two sets of brushes movable instead of one set. With respect to the other point, the torque of such a machine depends entirely on its keeping in synchronism.

Mr. Dobbie—My reason for asking that question was to find out if the motor will start on a full load.

Lieutenant Patten—No, it will not.

Mr. Lemuel Wm. Serrell, Jr.—How are the currents short-circuited through the rheostat when the ends of the rheostat are connected to the insulator blocks in the commutator.

Lieutenant Patten—The question is pertinent inasmuch as the term "insulated" was used in the paper. They are not insulated segments in the true sense of the word. They are all connected with each other and are of conducting material. The mistake is my own entirely in using the word "insulated" in any sense. The insulating segments referred to are the same kind of segments as the others. They are simply other segments not connected to the machine circuits and a little narrower than the others.

Mr. Serrell—The shaded portions, as I understood, are insulated blocks but as is now explained the shaded portion indicates a metallic connection separated from the rest of the commutator.

Lieutenant Patten—No, they are simply segments the same as the others, but are connected to an interior rheostat which is not in the circuit of the machine. I think, as has just been suggested to me, that they should be called "isolating" segments instead of insulating segments. They are segments not connected with the circuit of the machine, but simply to the rheostat, which is shown in the drawing, and this rheostat is intended to take the current at the time the brush leaves the group which is connected with the machine circuits and so prevent sparking.

Mr. H. Ward Leonard - Does the interruption of the current in the field occasion any loss of energy or heating of the field or lack of efficiency?

Lieutenant Patten—I may say in reply to that, and answer at the same time many kindred questions that might be advanced, that my experiments have been very limited, and that it would require considerable investigation to determine that point definitely. I have no doubt that it does limit the action of the field, but to what degree I do not know. But the current is broken when the machine is in synchronism at a point near its zero value. Of course, at 16,000 alternations per minute the interruptions are so short that the field could not readily lose its magnetism, but whenever there is a break of the current, there must be some slight loss due to that.

Mr. Allan V. Garratt—Is the resistance of the coils of the rheostat determined by experiment, and if so what relation do they bear to the resistance of the machine itself.

Lieutenant Patten—I have attempted to make the rheostat equal to the resistance of the machine, so that there would be as little change in the strength of the current as possible.

Mr. Mailloux—Is the resistance re-actionary or simply dead?

Lieutenant Patten—It is a dead resistance simply. It might, theoretically, be made to advantage of the re-active kind.

Mr. Mailloux—I should think a machine of this kind, although of great theoretical interest and an evidence of striking ingenuity, would be open to a defect arising from the wavy nature of the current, no matter how small the periodicity. There is always a time when there is no current. The magnetizing current through the shunt is a succession of waves. Consequently there would be an oscillatory tendency in the magnetism, a tendency to rise and fall. If the magnetic core is laminated and of soft iron, it will be able to rise and fall readily; rapidly enough to follow the fluctuations of the current. It does so in transformers. Of course, there is a slight reaction in the substance of the iron itself—its "viscosity," due to hysteresis; at the same time it is not sufficiently great to interfere with the rise and fall of the magnetism, and the more minutely the core is laminated the more rapidly the rise and fall would take place, so that if the magnetic field is made of a very finely divided magnetic medium and if the rise and fall can take place readily enough, it seems to me that there would be a certain amount of loss in consequence, which would be quite material, and also some loss from the reactions of mutual induction in the armature itself, for even when running at synchronism the current in the armature would be a succession of rises and falls, and although the magnetism of the armature is not reversed, yet the current is reversed through the coils; but that perhaps is not so disadvantageous as the constant rising and falling of current. I should think the loss due to mutual induction, particularly in the presence of a magnetic body of permeability and susceptibility, like the armature core, would cause an important loss, and I should not expect that the motor would show the efficiency of other forms, such as those suggested by Leblanc, in France, and by Mr. Mordey, in England.

Lieutenant Patten—I have only to say that there is a misconception in respect to the direction of the current in the armature. It is always the same. As to the induction due to the rise and fall of current, such loss is contemplated, and it is difficult to make out of an alternating current anything that does not vary. The essential fact, however, is that the current at work is due not only to the maximum and zero values of the electromotive force exerted, but to the current which is the result of the mean electric force, and that is the electromotive force out of which we desire to get the work. The current is of constant direction in the armature circuit, but it rises and falls as has been said, and the loss due to that is contemplated. I do not recall any machine described by Leblanc except those referred to as Mr. Tesla's and Professor Thomson's earlier form of motor. Beyond them I do not recall any machine in which these difficulties are not equally present.

Mr. E. P. Clark—I do not think that the rise and fall has very much influence, for when the armature is revolving at a high rate of speed, it is like a continuous current machine. While the speed is constant, the current will be nearly the same. There will be little rise and fall, due to the rise and fall of the alternating current.

Lieutenant Patten—The current in the field will necessarily be a re-directed current. It is represented graphically in figure 1.

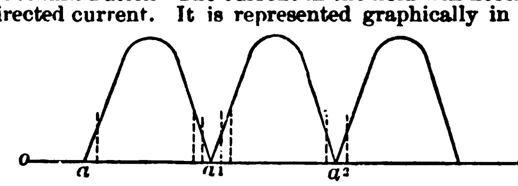


FIG. 1.

The commuted current at work, or more strictly, the electromotive force, would be cut off at the point a, we will say; if the machine is in synchronism at points a^1 and a^2, the interval would be a period of no current. The loss spoken of by Mr. Mailloux, will exist during such a slight period of no current whatever, as occurs at this point. A solid field core probably would not give up its magnetism during that short period, but a finely laminated one might.

Mr. Leonard—If you increase the load without fully loading the machine, and the load is removed, would there not be a tendency to race?

Lieutenant Patten—The limit of load in such machines is that which is required to throw it out by a full quarter of a period. I think it will not race. The tendency of course is if it races to go to the double synchronism. It has to go to the double speed or the quadruple, or else at the single speed at which it is synchronous. The action of this machine is not different from that of an ordinary alternating current motor where its maximum electromotive force is exerted when it is in synchronism within a quarter period of that of the generator. If it is overloaded beyond that point it comes to a state of rest or short circuits the armature—burns it up.

Mr. Leonard—Can Lieutenant Patten give us some description of the performance and sizes of the machines that he has made thus far.

Lieutenant Patten—Those I have made are too small to give any data which would indicate any efficiency worth talking about.

Mr. Leonard—What voltage did you work upon?

Lieutenant Patten—One hundred. I will draw the Mordey machine on the board and show the difference. (Figure 2.) The de-

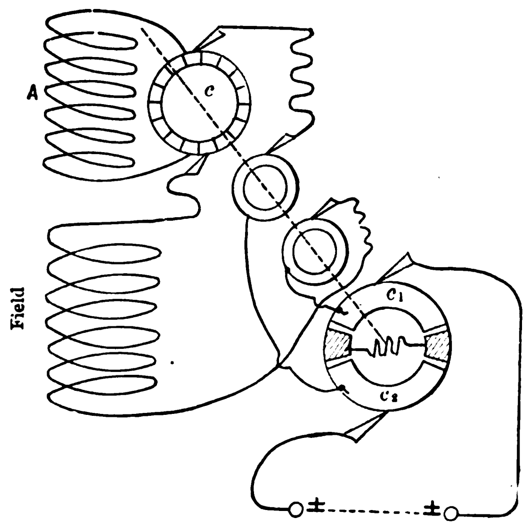


FIG. 2.

vice for rectification is fixed on the spindle of the moving machine. The dotted line represents the spindle of the machine. It is the commutator of an ordinary armature which is shown here. This being the armature circuit we will trace it simply as a closed coil from the upper point to the opposite point of the commutator and thence to the field. On the same spindle with this armature is placed another commutator which is shown in two parts. The upper and the lower halves are separated by isolated segments connected to a rheostat, such as I have described this evening. It is shown in this way, but in reality there are for each pair of segments a corresponding pair of isolating segments connected with the rheostat, so that after the brush passes one segment it connects with the rheostat, and so on. At the bottom is the source of the alternating current. These terminals go to the two brushes; bearing on the rectifying commutator which is broken up into alternating segments, part of them connected and part isolated. The live segments are connected alternately to two rings, one half to the segments of one ring and the other half to the other ring. Bearing on these rings are two brushes used as intermediate connections. Evidently this machine requires a speed of rotation such that the alternating current coming in at the two terminals will be commuted; then a direct current will flow from the brushes bearing on the continuous rings, and from these brushes we have a direct current through the armature and field in series, back to the outer ring and so returning to the source of the alternating current. This is spoken of by Leblanc as one solution of alternating current motors. It is not an alternating current motor in the strict sense of the word, because the alternating current is commuted before it is put into the machine. It is open to the same objection, of course, that the alternating current is broken at the point where it passes zero value, and the same remark applies to the field.

Mr. W. Forman Collins—When you break the circuit, the field will lose its magnetism. Will not the armature act as a short circuit across the field?

Lieutenant Patten—If the machine is in synchronism the current at this point is near zero, and the short circuit is then of little consequence.

Mr. Collins—It would induce very heavy sparking would it not?

Lieutenant Patten—It would if it were not for the isolating segments on which the brushes then bear and which offer a path for the current and so prevent its rupture.

Mr. Collins—Provided the field maintains some little magnetism.

Lieutenant Patten—Yes; if it gives it up entirely, of course the reactionary effect would produce sparking.

Mr. Dugald C. Jackson—I should like to ask if all these schemes are not beating around the bush to get a continuous current motor, and if the size of the machine when put on practical circuits is not prohibitive, and that consequently we cannot with any of these plans get an alternating current motor that will do the work on practical circuits economically.

Lieutenant Patten—I shall have to refer to the future for an answer.

Mr. Reed—Would it not be an objection to your laminated field that it would tend to cause the magnetism actually to become zero at each reversal?

Mr. Mailloux—I do not think that the magnetism would necessarily come to zero. We are not dealing with a simple magnetic circuit. In a simple magnetic circuit, in which there is no reaction against the lines of force in collapsing, you get a very quick collapse of the magnetism, and possibly absolute zero of magnetism in the interval between the two pulsations. You might explain this by taking an ordinary magnetic circuit—a ring for instance—with a magnetizing coil, the ring consisting of very finely divided wire. Now, if there is no reaction (Foucault currents, etc.) against the flow of lines of force; if we assume the ring to be fully magnetized and the magnetism suddenly released, and if we even eliminate the self-induction of the magnetizing coil itself, then we will readily see that the magnetism will fall almost instantly. There are experiments which go to show that the fall of magnetism would take place in an inconceivably small space of time under such conditions. But if we interpose in the path of the lines of force as they move, while rising or falling, a closed circuit or some other form that would tend to produce reaction then we get what we call "Lenz effects," and in that case we cannot get such a rapid rise and fall. Now in this machine the armature itself—the core and conductors are in the magnetic circuit; they form a part of it. Consequently at the time the magnetism is falling or rising there would have to be considered the reaction due to the conductors wound around the magnetic field itself, and also the conductors wound around the armature, and the currents induced in these conductors by either the rise or fall would necessarily tend to retard both the magnetizing and the demagnetizing. At first I thought the demagnetization would be very rapid. I still believe that there will be a great fluctuation, but I do not think that necessarily the magnetism would fall to zero. There would be a certain amount of residual magnetism during the intervals between the current waves.

Mr. Garratt—On the principle that sometimes "fools rush in where angels fear to tread," I would say that it does not seem to me that this question of the fall of magnetism of the field is such a serious one; although I am speaking not at all from experience, never having wound a machine of that character. But if I understood Lieutenant Patten correctly, the only reason why he laminates his field is to prevent undue heating at the starting of the machine. We have spoken of lamination as though it were a fixed thing. It may mean breaking up the core into two or three pieces or into a million. I suppose that it would be simply necessary to so proportion the laminations of the field that its magnetization would not fall unduly, and so that in starting the machine the field magnets would not get unduly heated. It seems to me that it could be got at empirically in the natural process of building these machines of various sizes, and that it cannot be got at by pure inductive reasoning; but the natural principle would be that it should be so proportioned that it would not be a practical difficulty.

Mr. E. T. Birdsall—In small machines, we know that in breaking the magnetic circuit, the magnet loses its power very quickly. In large machines, of 20 or 30 h. p., it is known that magnets will not lose their magnetism for from two to three seconds, where the cores are very large and have a large amount of iron in them. In that case we might arrive at a mean degree of lamination, which would not produce too much heating. We might arrive at a size which would be a mean size of machine and which would give the best effect. It also struck me in regard to the magnetism falling, that possibly, it does not matter so much whether the magnetism does fall, because everything else is zero at the same time the magnetism is zero.

Mr. Ludwig Gutmann—I think the motor just described is very ingenious; but we cannot discuss the motor itself as it stands alone. We have to consider it in connection with the circuit, because we want to transmit power. Synchronous motors generally can not be thoroughly successful because they will not answer all purposes. The same speed is not required in all cases. This motor of course is a step forward, because it can be so arranged as to permit the introduction of motors of different speeds on the same circuit. Nevertheless the motor is of the constant speed type, while in practice a variable speed is often desirable. I see one serious objection to the motor, and that is that it has the high potential current in the motor armature itself, and in case of any trouble arising, the person who has to handle it, is immediately exposed to the danger of the medium or high-tension current in the main wires. That is the most serious trouble that I find with it. Otherwise I believe it would answer many purposes, because I think the motor will do its work well. It appears the motor would not start from state of rest with any load on it, and would need a loose pulley so as to get up to synchronism before the load could be thrown on. This, of course, would be a weakness, but not objectionable; but the first mentioned objection I think is a serious one—as the machine requires a high potential. I do not think that this motor can be worked with low tension currents, because, especially to produce 3 or 4 h. p. or more the self-induction in the coils in connection with the mass of iron is great. If such a motor should be placed on an ordinary alternating current circuit used now, having about 1,000 volts and there is any sliding connection and commutators to get loose, or brushes to wear out, we should always have to send experienced men to the spot and they are exposed to the thousand volt currents, and on this ground I do not see that it would quite answer the purpose—I mean that

it would not be a solution of the problem, but a decided step in that direction.

Lieutenant Patten—As to the high potential of the machine, of course in the general description I have given, the source of alternating current is represented as any source of alternating current of high or low potential, and so no special reference is made to its use as a high potential machine. The source of alternating current is presumably one of suitable character to meet the conditions in which it is to be used. With reference to the further difficulty mentioned, accidents will happen with any kind of machine either direct or alternating, while the other forms of motor have some advantages in having ring contacts and sliding brushes that require no attention. The disadvantages that are introduced by bringing in the use of brushes, are incident as well to the ordinary forms of motors with which we are familiar. We are not so familiar with the kind that have no commutators that we have got used to their ease and simplicity of working. The second set of brushes are not, as I said before, brushes in the ordinary sense, and do not require adjustment and care. If a high potential machine is used, of course the ordinary precautions will have to be taken. It is not quite within the province of the alternating current motor to make the alternating current safe for everybody who uses it.

Mr. Gutmann—I wish to point out that alternating current motors have this drawback, that the coils surrounding the iron core need a certain pressure to make any current flow through those coils—to get any power out of the motor we have to force the current through. Now to produce 5 or 10 h. p. we need an exciting power, we need a certain number of ampere turns in the field. To have this certain number of ampere turns we must have a considerably higher pressure than might be supposed. We must have an armature to perform the work and to obtain the torque. Consequently I think it is impossible to realize a large amount of power without using medium or high tension currents for alternating current motors. Another point is that we have to consider that alternating current motors will not always be placed in the hands of scientists, but will have to be used by inexperienced men, consequently I think this is a weakness in the motor if we have loose or sliding connections in a high potential circuit. I should prefer to have a motor, for instance, like Professor Thomson's, in which the high tension current is fixed—no rubbing contact, and I think Mr. Tesla has shown us one way in which to construct a motor without any commutator or brushes, and I believe there are many electricians hard at work to get something similar without a commutator, which is far preferable; but we will have to wait sometime before we shall get that. At all events, Thomson, for instance, has given us a motor in which the field alone, is in the high tension circuit. This is the main drawback that I find to this motor. If we had no rubbing contact in these motors, it would be a great advantage. As it stands, the armature is in series, or is in connection with the field, and consequently we have an increased self-induction, and we need a greater power and greater tension for this class of motor than we would if we had only to energize one of the two parts, either the armature or the field with the current, and that is the reason I said that there is a serious difficulty in introducing it into ordinary use.

Lieutenant Patten—In general reply to all, it might be said that as to making a rival to the direct current motor, no attempt is made in that direction. The object is to make a machine which has less weight and more efficiency at the outset than one that has been improved by the ablest talent of the world for the last five or six years. The question is radically whether or not we can make an alternating current motor at all. If we could, the question might be put, what are you going to do with your current 10 miles from here if you cannot get an alternating current motor? I think if the efficiency of such a machine drops to 60 per cent. it would not be a vital question in the problem with reference to the great importance of the transmission of power to great distances.

The Chairman—I now have much pleasure in announcing that for our October meeting we shall have a paper by Mr. Thomas D. Lockwood, a member of our board of managers, who has recently returned from a prolonged trip through Europe, and has made a great many observations on electrical development there, and who purposes to lay before us the pith of his notes on the subject. The paper will be read on October the 8th.

TELEPHONE CONVENTION AT MINNEAPOLIS.

The Eleventh Convention of the National Telephone Exchange Association, at Minneapolis was, in many respects, one of the most enjoyable meetings ever held by the organization. The adjective should be particularly emphasized. The delegates extracted no little enjoyment out of the trip to Minneapolis and out of the several features incidental to the meeting. How much profit was extracted from the sessions it would be hard to estimate, inasmuch as outsiders were not allowed to hear the deliberations. A party of delegates and friends started on Sunday morning, September 8, in a special train from New York. A walk through the coaches revealed the presence of a large number of ladies with the delegates. There was an absence, therefore, of some of the uproarious hilarity and horse-play which sometimes characterizes an electrical party on its travels. Arriving in Chicago at 9.30 Monday morning, the delegates became the guests of the Chicago Telephone Co. and the Central Union Telephone Co. They gathered at the rooms of the Chicago Electric Club, where lunch was served. Members of the club who were present were congratulated on their new rooms. After lunch the guests enjoyed a carriage ride about the city and were given, as C. H. Wilson, superintendent of the Chicago Telephone Co. said, an opportunity to see the sites of the buildings which will be erected for the World's Fair in 1892. The drive ended at the depot where the train was in waiting to convey the party to Minneapolis. The company was joined by about 20 persons in Chicago. There were vague rumors in circulation that the party was not to be allowed to sleep that night, but the only disturbance inflicted upon the travelers was from the tuneful voices of the "Telephone Minstrels" in the smoking room. For an hour Messrs. Degenhardt, Hibbard, Price, Knight and McQuaide lifted their voices in melodious strains, and regaled the listeners with jokes, to which not even the Cliffords from Boston could object. After this silence reigned save for the occasional snap of a card or the chink of a chip from a curtained smoking apartment.

The train drew into Minneapolis about 9.30 Tuesday morning. The delegates rushed for omnibuses and were driven to the West Hotel—a structure by the way, which Minneapolis prizes as the apple of its eye. It is a splendid building, and it afforded excellent accommodations and entertainment for the telephone party.

At 11 o'clock the delegates and a fair representation of outsiders gathered in one of the meeting rooms in the hotel. The visitors had been warmly greeted by Messrs. Sprague, McKinstry and Glidden of the local telephone company. President Metzger rapped for order, and the 11th convention was begun. The writer listened to some of the proceedings only. The reports of the secretary and treasurer were presented, and very appropriate action was taken on the death of George L. Phillips, president of the Chicago Telephone Co. and Central Union Telephone Co. Then the association went into executive session. The outsiders filed gloomily out. General Barney followed the last retiring shadow, closed the portals and posted a sign of warning on the outside of the doors. Only the outsiders were driven out, but it looked rather dubious for the honorary and associate members at one time. A resolution was presented by a delegate providing that only members be admitted. He said if it was proposed to have an executive session he would like to have one which meant something; he would admit regular members only. He did not believe in half-way measures. This, of course, brought Mr. Lockwood to his feet, as he did not propose to be dismissed in any such summary fashion when telephone matters were under discussion. A settlement was at once effected, and the honorary and associate members were allowed to remain.

No one apparently paid the slightest regard to the sanctity of the executive session. If anybody wanted to know what was going on he had only to ask questions of the first member issuing from the secret chamber. Members were perfectly ready to answer any question and to disclose any information. General Barney was the exception. He was as dumb as an oyster about all convention proceedings. If a person with notebook in hand asked for the names of those who had participated in the discussion of any topic and for a digest of their remarks, the information was always forthcoming.

The reason for holding secret session was to be found in the fear of half-a-dozen members that the daily press might comment on the paper on a "New Era in Telephony," by Messrs. Carter, Hibbard and Pickernell, and begin to cry for metallic telephone circuits for the improvement of the service. It was also feared that what might be said on the subject of induction from lighting and railway circuits might be quoted on some inconvenient occasion. The great majority of delegates cared little about the matter one way or the other. They like to see their proceedings printed at length, because it looks well, but they were ready to defer to the wishes of their timid brethren. It was rather comical, however, when some member's remark uttered cautiously in the secret chamber was repeated unconcernedly in the lobby of the hotel by a member who had just stepped from the session room to buy a cigar. In the evening the delegates were obliged to do something, and theatre-going seemed to afford the simplest solution of the problem, so the local places of amusement were well patronized far beyond their merits. The state fair and the Minneapolis exposition came in for their share of patronage. Minneapolis was brilliantly illuminated in honor of the exposition. Two hundred arc lights with red, white and blue globes were suspended from wires on the bridge and on the street leading to the building. The members also visited the local electric light station which is being considerably enlarged, and the Pittsbury flouring mills.

On the last day of the convention one of the most interesting matters presented was the copper question. A resolution was offered asking for the appointment of a committee to co-operate with a similar committee of the National Electric Light Associa-

tion to present to Congress a petition for the abolition of the duty on copper. The majority of the members in their attitude toward this question were in the same placid state of mind as they were in considering the matter of executive sessions. On the whole, they favored the abolition of the duty on copper, but they preferred to drop the matter rather than to take action which could give offense to the most timid brother. So the matter was passed by without any action whatsoever.

The real business of the convention closed on Wednesday night, and Thursday was devoted exclusively to pleasure. At 9.30 carriages were at the door of the hotel, and for an hour or more the visitors were given an opportunity, while driving, to admire the beauties of Minneapolis. It is a beautiful city. The buildings are imposing and the architecture is varied enough to make the total effect extremely pleasing. The public library building, which is just completed, is one of the most magnificent buildings used for the purpose in the country. The city contains a great number of beautiful homes, and one cannot drive through the residence districts without arriving at the conclusion that the citizens of Minneapolis have been wonderfully prosperous. One does not gain the impression that this part of the city is new. It seems to be substantial and laid out with marked good judgment. The visitors left their carriages at the motor station and said good bye to Minneapolis. A trip of a few miles brought the party to Minnehaha Falls. The visit here was rather disappointing as but little water dashes over the falls, "about as much as from a fire plug," as one unromantic individual put it. The party was photographed, and then set out for St. Paul. Carriages were taken at the depot and for an hour and a half the visitors were driven about the city, so that they had an opportunity to compare the beauties of the twin cities. St. Paul is all up hill and down. A toboggan slide could easily be made out of any one of 50 thoroughfares. It is a beautiful city, with many splendid buildings and charming homes. If the visitors formed judgments about the relative merits of the two cities, they were polite enough to suppress them, so that no offense was given to the residents of either.

A banquet at the Hotel Ryan lasted for two hours. It was skillfully arranged, and everything passed off well. The speeches were more entertaining than usual at such gatherings. About 30 ladies were in attendance. They sat at a table by themselves. A supply man who entered the banquet late had the audacity to take a seat at the ladies' table; what is more, he retained his place until the close of the banquet, and alone, among all the gentlemen of the gathering, spoke to a lady during the proceedings of the afternoon. For the pleasures of the day the visitors were indebted to the North Western Telephone Exchange Co., which had invited the delegates to be their guests for the day. The representatives of the company were untiring in their efforts to make the day enjoyable. To Messrs McKinstry and Glidden of the company, the party was under especial obligation for many acts of courtesy. Taking everything into consideration, as was stated at the outset, the Minneapolis convention was a highly enjoyable meeting.

GAS ENGINES.

At the recent meeting in Paris of the Institution of Mechanical Engineers, a paper was read by M. Edouard Delamere-Deboutteville, entitled "Gas Engines, with a Description of the Simplex Engine." Before entering into details of the Simplex engine, an historical account was given of the inventions connected with gas engines from as long back as 1791, when John Barker published his description. Some 700 patents have been taken out since 1860, the date of Lenoir's arrangement, for improvements or inventions connected with prime motors actuated by gas. The author passed rapidly over the most important inventions since 1791; but his knowledge does not appear to have been quite brought up to date, seeing that no mention is made of such machines as the Atkinson, or the Griffin, which figured so prominently at the Society of Arts motor trials; while in regard to the Otto engine, some details are adversely criticised, which have been abandoned by the makers for some considerable time past. The various methods of ignition are reviewed, the author considering that most of the troubles in connection with the successful working of gas engines arise from the difficulty of obtaining a satisfactory means of igniting the charge, and he comes to the conclusion that ignition by the electric spark is the most effectual and certain in its action, and the mode, a continuous stream of sparks, adopted in the Simplex engine, has overcome all the difficulties that occur when dealing with various qualities of gas. The engine is constructed on the four-cycle plan of Beau de Rochas, but possesses many novelties in the details. The slide is simple, merely a cast-iron plate with two holes; the air and gas are not mixed in the cylinder, but in a separate receptacle outside, and thence drawn into the cylinder by the motion of the piston. The regulation of speed is controlled by the admission or non-admission of a charge, the governor used being either an air one or of the pendulum species. In engines over 20 h. p., the motor is constructed in the ordinary manner, and the external mixing chamber dispensed with. Some trials of this engine give economical results; in one case, with an effective horse-power of 6.70, the consumption of gas—ordinary town—was 22.09 cubic feet per effective horse-power. A 50 h. p. engine, using Dowson gas, with a load from 35 to 40 electrical horse-power, consumed 51 pounds of English anthracite in the Dowson generator per hour; *i. e.*, about 1.3 to 1.148 pound of coal per electrical horse-power hour.

In the course of the discussion which followed on the succeeding day, Mr. Holroyd Smith took exception to the historical part of the paper, and showed that Messrs. Crossley were not the originators of the system they used, but Beau de Rochas. No description of any modern engine, with the exception of the Otto, was to be found in the paper, and he considered that to use electrical ignition in place of the available natural means, was to take a retrograde path, and make the Simplex into a complex motor. Professor Kennedy said there were many good engines in the market which might have had a place in the paper, and it would have been interesting and instructive to compare them with the Simplex; he did not concur in the author's strictures on the use of the igniting tube. The system of governing used in the Forward engine is within a range of 20 per cent. by dilution of the charge, and beyond this by "hit or miss." He thought the pendulum governor a very ingenious device. Mr. Scott Moncrieff differed from Mr. Holroyd Smith as to the use of electric ignition. Mr. Kapp remarked that the production of a spark from a dynamo necessitated a high speed, but he had seen in the exhibition, applied to a gas engine, a dynamo in which the armature was oscillatory, not rotary. The motion was obtained by a spring and trigger, and though the flywheel was traveling slowly, an effective spark was produced by the rapid motion of the armature. It was stated by Mr. Shields that the life of an ignition tube might be safely reckoned at a fortnight or three weeks, not two or three days as had been inferred. M. E. Delamere Deboutteville, in replying, said that he had found the electric spark possess many advantages over the other modes of ignition when using poor gases; the battery he used lasted from 200 to 300 hours without recharging. It had been asked why there was over compression at the end of the stroke. In this engine a part of the stroke was made before the ignition took place. This was that pressure might not be put on the crank pin when the engine was on the dead point. As a certain definite compression was required to get the best effect of the explosion, the mixture had to be over-compressed at the end of the stroke in order to have the required amount of compression when the charge was ignited.—*The Electrical Review* (London).

THE INTERNATIONAL ELECTRICAL LABORATORY AT PARIS—TARIFF OF CHARGES FOR TESTS.

The following table is taken from *La Lumière Electrique*:—

The committee of the International Electrical Laboratory in Paris, have fixed upon a tariff for experiments made for public or private account. The prices have been increased somewhat, the rates formerly charged having been found inadequate.

TARIFF OF THE LABORATORY.

1. *Experiments, with a certificate.*

5 fr. 1. Kilometric conductivity of a metallic wire.
" 2. Conductivity of an electric light carbon.
10 fr. 3. Resistance of insulation of a dielectric.
" 4. Constants of a metallic wire (diameter, conductivity, metallic resistance, pliability).
" 5. Gauging a commercial ammeter.
" 6. " " voltmeter.
" 7. " " electro-dynamometer.
" 8. " any galvanometer whatever.
" 9. Constants of a condenser (capacity, insulation, etc.).
" 10. Gauging a standard battery (E. M. F. at a certain temperature).
" 11. Photometric intensity of an incandescent lamp (in various azimuths).
" 12. Photometric intensity of a gas jet
" 13. Gauging of a resistance at a certain temperature.
20 fr. 14. Experiments on an electric insulator (under various conditions).
" 15. Photometric intensity of an arc (in various azimuths).
" 16. Experiments on a lamp carbon (conductivity, durability, steadiness of arc).
" 17. Experiments on a formed accumulator (E. M. F. capacity, curve of discharge).
" 18. Experiments on a battery (variations of the E. M. F. and of the resistance).
25 fr. 19. Gauging a meter for electricity.
" 20. Gauging a box of resistance coils (at a certain temperature for continuous currents.
" 21. Experiments on a cable (conductivity, capacity, insulation after immersion for 24 hours in a bath @ 24° C.).

25 fr. 22. Experiments on a dynamo machine or magneto-electric machine of 1 h. p. and under (E. M. F. resistance of circuits, characteristics, etc.).

50 fr. 23. Gauging of an exact amperemeter or voltmeter.

" 24. Experiments on a standard of resistance (resistance and variation with temperature).

" 25. Experiments on a standard of E. M. F. (E. M. F. and variation with temperature).

" 26. Experiments on a dynamo machine of from 1 to 10 h. p.

100 fr. 27. Experiments on a dynamo machine of from 10 to 15 h. p.

REDUCED RATES.

Gauging of electric meters in series (when instruments are identical).

In series of 5, 50 fr. per series.
" " 10, 75 " "

Gauging of commercial ammeters or voltmeters in series (identical instruments).

In series of 5, 25 fr. per series.
" " 10, 45 " "

Experiments on cables.

In series of 4, 50 fr. per series.

Experiments without certificates according to time occupied.

At from 15 fr. to 25 fr. per day of eight hours.

THE PARIS ELECTRICAL CONGRESS.[1]

The first meeting of the congress was held on Saturday, August 24th, for the purpose of organizing it. As acting president M. Mascart was chosen, and as honorary presidents Sir William Thomson and MM. Cochery and Berger. The following is a list of the vice-presidents and the countries they represent:—Professor Ferraris (Italy), Herr Kareis (Austria), M. Potier (France), Mr. Preece (England), M. Rousseau (Belgium), M. Stoletow (Russia), Professor Weber (Switzerland). M. Joubert was elected general secretary. To facilitate business, it was arranged to divide the congress into four sections, viz.:—

I. Units of Measurement.
II. Industrial Applications.
III. Telegraphy, Telephony, and Signals.
IV. Electro-Physiology.

Reports on various branches of electrical science had been prepared beforehand, and were distributed to the members. Generally speaking, these reports were retrospective, and intended to show the development and present position of each branch. The subject of "Electric Standards" was treated by M. Pellot, "The Measurement of Electric Energy" was treated by M. A. Potier, "Telephony" by M. de la Touanne, "Transformers" by M. Picou, "Dynamos" by M. Hillairet, "Electric Lighting" by M. H. Fontaine, and "Electro-Physiology" by M. d'Arsonval. It would lead us too far were we to give a summary of all these reports, but we may give the gist of some of those which deal with electric lighting apparatus. As a "transformer," M. Picou defines every instrument by means of which the electric energy in one circuit is instantaneously translated into a second circuit. The condition of instantaneity is essential and precludes, therefore, the application of the term "transformer" to a secondary battery or condenser, since in these cases a longer or shorter time may elapse between the work being put into and taken from the apparatus. The action of a transformer must, therefore, depend upon induction varying periodically, and M. Picou distinguishes between three possible methods: (1) Periodic variation of the primary current, as in the ordinary alternate transformers; (2) displacement of circuits, as in rotary transformers or motor generators; and (3) deformation of circuits, which method has hitherto not been practically applied. Alternate current transformers date from 1878, when Jablochkoff showed a set of apparatus at the Paris exhibition. Gaulard and Gibbs followed with similar apparatus, in 1883; but till then the leading idea was to arrange the primary coils of transformers in series, which led to great difficulties in regulation. In 1885, Dr. Hopkinson and Messrs. Zipernowski, Deri, and Blathy advocated parallel working, and the employment of a closed magnetic circuit, the adoption of these improvements leading to a rapid development of central station lighting. M. Picou considers that all the different modern transformers, when well made, are of about equal value in efficiency, which he gives as 90 to 95 per cent. at full load. He next gives a theory of the transformer, and contrasts the alternating current transformer with the motor generator. His remark that the former are at a disadvantage because alternating currents cannot be used for the transmission of power, will, however, scarcely be indorsed by other electrical engineers.

1. From *Industries*, August 30th and September 6th, 1889.

M. Hillairet's report on dynamos is also mainly retrospective. Beginning with the Gramme machine of 1869, he shows the gradual development of the dynamo. The first machines were small, and the torque scarcely reached four kilog.-meters, whilst nowadays machines requiring a torque of 1,000 kilog.-meters are by no means exceptional. In the report on electric lighting, M. H. Fontaine sketches the history of this industry from 1874, when several works in France adopted the arc light. In 1878 came the electric candles for use with alternating currents, and three years later the glow lamp. Lamps are divided into four classes: (1) Arc lamps, (2) candles, (3) ordinary glow lamps, and (4) high candle-power glow lamps. As regards the life of glow lamps, M. Fontaine states that a life of 1,000 hours can be easily reached if the lamp is run with four watts per candle; but if run with three watts, the life is only from 300 to 400 hours.

The first meeting of the congress for technical business was held on Monday, 26th, when M. Crova read a paper on "The Photometry of Electric Lamps."

After referring to the great uncertainty of photometric measurements as ordinarily carried out, the author described his method, according to which he is able to determine not only the illuminating power, but also the exact tint of the light emitted from any glow lamp. At first he employed a spectroscopic photometer, and found that the light emitted from a carcel lamp had a wave length of 582 millionths of a millimeter, this being the point where the spectroscopic curves of light from the lamp and of sunlight intersect. By determining the curve for a glow lamp, and comparing it with that of the carcel lamp, the tint of the former could thus be defined. As, however, the manipulation of a spectroscopic photometer requires too much care for everyday work, M. Crova simplified his apparatus by interposing into the rays of the glow lamp a screen consisting of a solution of chloride of nickel 5mm. in thickness. All lights seen through such a screen have the tint of the carcel, and the reading on the photometer, gives, therefore, directly the percentage of orange light as compared with the carcel. The amount of red or orange light given out by a glow lamp varies naturally with its temperature. Thus a certain lamp consuming 30 watts contained 1.33 times the amount of red light as compared with a carcel, whilst the same lamp run with 90 watts contained only 0.88 of this amount. It is thus possible to express the amount of red light by a figure, and the author suggested to fix the standard voltage of the lamp so that the amount of red light given out should be exactly equal to that of the carcel. The illuminating power of a glow lamp is different in different directions, and for exact measurement it was hitherto customary to construct a curve of horizontal intensities, from the area of which the mean intensity could be computed. This is a very elaborate process, and to avoid the necessity of it M. Crova mounts the glow lamp to be tested on a vertical spindle, which is revolved at considerable speed by an electromotor. The photometer gives then directly the mean horizontal intensity. To show that the "normal voltage" as marked by the manufacturer on glow lamps is by no means a correct guide to the consumer, he gave the results of tests with three lamps apparently identical. Calling the lamps A, B, C, the figures obtained with an expenditure of 30 and 90 watts respectively were as follows:—

	A		B		C	
Energy supplied to lamp in watts....	30	90	30	90	30	90
Percentage of red light emitted as compared with the carcel........	133	88	118	79	112	87
Illuminating power in carcels........	0.130	3.68	0.125	3.50	0.150	3.25

The author suggests that the "normal voltage" of a lamp should be that at which the light emitted from it has exactly the same color as the carcel. In testing arc lamps he employs a diffusion photometer, in which the rays from the arc are passed through a plate of ground glass and diffused. A screen, the opening of which can be regulated by a screw, is used to vary the amount of light passing through the glass and received in the eye piece, so that the illuminating power of the lamp can be determined from the size of the aperture.

The discussion on this paper was commenced by M. Picou, who took exception to the author's proposal for the determination of the normal voltage. This depended on so many other considerations that it could not be fixed beforehand. An important factor, the speaker contended, was the cost of power. Where the latter was low, as, for instance, in installations where water power was employed, and the lighting was direct from the dynamo, it was more economical to run the lamps at low temperature; whilst in other cases, notably when a storage battery and steam power or gas were employed, the lamps should be run high, as it was more important to save power than reduce the annual lamp bill.

The author remarked, in reply, that it had been his aim to define scientifically what the normal voltage of a lamp should

be, but not to impose upon the user of the lamp that he should work it at that voltage. The further discussion on this paper was adjourned to Tuesday.

M. Bede, a Belgian engineer, then described a combined system of heating buildings by steam or hot water, and lighting by glow lamps, which he had adopted with good results in a warehouse. In this instance he had the choice between a separate plant for each purpose or a combined plant. In the former case he could have employed a condensing engine for the lighting service, and thus saved fuel; but he preferred the more wasteful non-condensing engine, because the exhaust could be utilized for heating. There was, however, the difficulty that the heating was required all day long, whereas the light was only required for a few hours in the evening. This difficulty might be overcome in two ways. It was possible to store heat in some special apparatus, or to employ a generating plant just large enough for the heating service, and to store electricity in a set of accumulators. He selected the latter expedient, and found that, although the cost of the whole plant was about the same as that which would have been incurred had the lighting and heating apparatus been kept distinct, the working expenses were less. During the day the engine was kept employed in driving the charging dynamo, and the exhaust steam was utilized for heating, whilst in the evening both the dynamo and the battery were used for lighting.

(*To be continued.*)

ELECTRICITY ON THE WEST END STREET RAILWAYS.

PRESIDENT H. M. WHITNEY'S OPINIONS.

At a meeting of the stockholders of the West End Railway Co., of Boston, on July 25, 1889, called for the purpose of taking action in reference to an increase in the capital stock of the company, a very interesting address was made to the stockholders by President Henry M. Whitney, which it has been our intention to print in full, but owing to the pressure upon our space we must ask our readers to content themselves with an abstract of its most important points.

President Whitney referred to a statement made at the last meeting in reference to certain routes which were being equipped by the company for the purpose of testing the system of electric traction, and said that since that time these routes had been put in operation. They had not only met the highest expectations of the company, but had more than fulfilled the hopes of the community. So far as he was aware the sentiment throughout the section covered by the electric road was entirely unanimous; every community reached by it was extremely anxious for the extension of the electric service. On July 6th the electric line from Harvard square to Arlington was opened, and the very quickest time it had ever before been possible to make—35 minutes—had now been reduced to 20 minutes schedule time. The company now came before the stockholders and the community in this position:—The community are satisfied that the system will accommodate the people, while it was so much cheaper in its operation that it was advisable for the company to put it in at the earliest possible day. Moreover, the company finding how communities are interlocked with each other, found itself absolutely compelled to take the system up wholesale; in making the change from horses to electricity it was necessary to include the whole system.

The electrical centre of Boston inside of Charles River was at Pleasant street and Shawmut avenue. As the travel increased to the Highland district, the electrical centre will in a short time be almost coincident with the Hinckley Locomotive Works property, which the company had recently purchased for a power station. For twenty-five years to come every electric car inside of Charles River, including South Boston, could be economically run from that station.

The operation of the cars would involve at no distant day the furnishing of 10,000 h. p., costing in a large plant about $100 per h. p. A good double motor cost $3,000, and a single motor $2,000. They were running to-day between 700 and 800 cars, and if the experience since electric cars were introduced is any criterion, they should not only want those but an immense number more immediately. Then there was wire and poles, new construction, new equipment, new track, etc., which all went to make up the four millions and a half of new stock which must be issued to make this change. Few of the stockholders realized the actual situation of the company, whether the change be made or not. The present investment, made up of road, rails, cars, horses and equipments represents $11,619,172. The steady regular increase was 10 per cent., but if the service is increased 10 per cent., the number of horses and cars, value of real estate and general equipment must be increased in the same proportion. The West End company did not own a single car, horse, or foot of track in excess of its needs. So much for the increase with horses; but what were the facts as to electric roads? The Arlington line had been in operation seventeen days. For the same time last year the receipts were $2,721; the receipts for this year were $6,273, absolutely 150 per cent. increase for every single day of running. Now look at the Brighton line. The total receipts for June last year $4,426, for June this year $8,759. There are the number of people to be provided for. The directors have no knowledge how large this increase of travel will be with electric cars, but they have seen enough to know that it will largely exceed all experience. There are perhaps 50 or 75 miles where it would be best to put in new rails. For example, the time from Arlington to Harvard square, four miles, is 20 minutes, 12 miles per hour; the average rate of speed of elevated roads in New York is only 10.89 miles per hour. *The West End electric cars are now making in the City of Cambridge a rate of speed absolutely one-eighth more than the elevated trains in New York.* This showing had entirely changed the sentiments of the people of Cambridge, who had been so strongly in favor of an elevated road. The West End company ultimately expected to make 15 miles an hour; they could certainly reduce the time very materially, and utterly dispose of the question of an elevated road. The company had 776 cars standing on its books, at a little less than $1,000 per car, which were as good as new. It need not cost $100 apiece to turn them into electric cars, so it was of little consequence whether they used the old cars or bought new ones. There would not be a dollar lost in car equipment in changing from horses to electricity. It was the custom of the company to charge every month to repairs, depreciation on horses, and renewals, 12 per cent. a month; in round numbers $150,000 a year to depreciation in horses. It would be utterly impossible for the company to make the change in haste. It will be made so gradually that the depreciation of horses will only be felt in the accustomed way, as it is now charged from month to month.

Finally, as to the cost of operating. The question that largely concerned the stockholders, especially with reference to increase of stock. The average cost of motive power by horse for the past six months is 10.16 cents a mile, which does not include drivers, conductors, starters, repairers of track, and all such things which is the cost of horse motive power. All the company's experience in the actual operation of the electric road from Allston, with all the disadvantages of pouring power into a leaky conduit and absolutely losing it, with the disadvantages of operating from a remote point, the cost of fuel required is only 1⅓ cents per car mile. The directors believe that the cost of power, engineering, engineers, and all other expenses have been paid at a trifle over 3 cents per car mile. The cost of engineers and so on is large in proportion, because the mileage is small. The directors believe that the cost of power, operating, engineers, and every expense at the power-house would not exceed 2½ cents per mile, and the engineers predicted it would be very much less. The estimated cost of taking care of the motors and of the overhead line would not exceed 2½ cents per mile more. There was a clear saving of 5 cents a mile, to say nothing of the further saving in the cost of operation of the road due to increased speed, which anybody could figure for himself, and which was a very important feature.

What did all this mean? It meant that with the electric system the West End company could give the community all it needed in the way of rapid transit, greater accommodations, more frequent trips. All those things took money; but if the company were to go forward and fulfill the expectations of the community, and justify the trust placed in it in reference to the transportation of passengers, a trust that concerned the 300,000 people that crowded their cars daily, the directors must be placed in a position to get the money to do this work.

At the close of Mr. Whitney's address, Mr. Hyde moved that the directors be authorized to petition for leave to increase the capital of the company to the amount of $4,500,000, which was agreed to and passed.

COLLEGE NOTES.

Cornell University—Sibley College.

The entering class at Sibley College numbers 101. All of the new men have entered either without conditions or with an account which balances up ahead of the requirements. Of this number 52 are registered M. E., and 49 in the E. E. course. It is very probable that a large number of those in the M. E. course will be registered E. E. before the completion of their course. About 20 more, at present registered in other courses, desire to enter Sibley College, and will be admitted when conditions are made up.

The men in the upper class have not all registered as yet. At present in the E. E. course there are 40 sophomores, 37 juniors, 22 seniors, and several resident graduates.

The chemical laboratory, which is being built, will when finished be the finest and most completely equipped in the country. Its completion is anticipated with considerable pleasure by the faculty and students in the engineering courses, as the quarters now occupied by the chemical department will be at the disposal of the department of physics.

Several changes have been made in the corps of instructors since the close of the last college year.

E. P. Roberts, M. E., Professor of Electrical Engineering, resigned to accept a position with the Brush Electric Co., Cleveland, O.

Harris J. Ryan, M. E., '87, Instructor in Physics, has been appointed Professor of Electrical Engineering. This appointment will be greeted with gratification by all the students who have formerly been under Professor Ryan's instruction.

Assistant Professor Moler will have charge of the seniors in electrical engineering in their physical laboratory work.

Ernest G. Merritt, '87, has been appointed Instructor in Physics.

The course of instruction for the senior E. E.'s has been slightly changed. For the next term the work will be as follows :—

Lectures by Dr. Thurston on Thermodynamics, five hours per week.

Lectures by Dr. Nichols on Electrical Measurements, one hour per week.

Lectures by Professor Ryan on Dynamo Construction, Design of Lighting Stations, Systems of Wiring, Storage Batteries, etc., two hours per week.

Draughting and Machine Design, under Professor Ryan, nine hours per week. This work is supplementary to the lectures.

Physical laboratory, under Professor Moler, ten hours. This work consists of dynamo tests, the calibration of instruments, etc.

Mechanical laboratory, under Professor Smith and Mr. Bissell, 5 hours per week.

This work consists of the calibration of steam gauges and dynamometers and the efficiency tests of steam, gas and caloric engines, water motors, boilers, etc.

Shop work, six hours per week

An elective course of two hours per week in the mathematical theory of the dynamo, under Mr. Merritt, is open to seniors.

A new course in elementary physics, covering two years instead of one year, as hitherto, will be begun this year.

There has been a great demand for Cornell graduates in electrical engineering this year. All the graduates in the class of '89 have received positions, and several applications for others have been received by Dr. Nichols.

The Westinghouse company have presented a Waterhouse arc dynamo to the department. Additions have been made to the storage batteries during the summer. These batteries have been made to take the place of primary batteries for use on the chronometers and the gas-lighting apparatus.

During the summer Professor Ryan and Mr. Merritt have been at work on alternating current curves and converters. The results are very satisfactory, and will be published in a short time.

An electrostatic watt-meter and electrometer for alternate current work, invented by Professor Harris J. Ryan, was exhibited at the meeting of the American Association for Advancement of Science, recently held at Toronto, Ont., and excited much interest.

This instrument is new as to methods. The electrometer needle and quadrants were made cylindrical in form. To the needle was attached a magnetized steel mirror. The needle was hung by a single silk fibre, and metallic contact was made to the same by means of a very fine platinum wire. About the quadrants and needle, with its plane in the magnetic meridian and the steel mirror at its centre, was arranged a coil of wire, as in a tangent galvanometer. The electrometer needle was deflected and then brought back to its zero position by balancing with a current in the coil surrounding the same, whereby the magnetized mirror was acted upon by a current of the opposite sign to that acting on the needle. The current was then a measure of the difference of potential, to which the electrometer had been subjected.

ELECTRIC LIGHT AND POWER.

A Thomson-Houston motor is now employed to operate a type-setting machine in the composing room of the Chicago *Evening Journal*.

The Windsor theatre, on the North Side, Chicago, is illuminated by electric lights throughout. The entire plant was furnished by the Chicago Edison company. About 800 lights are used. The dynamos are of 25,000 volts capacity each. A Russell 80 h. p. engine supplies the necessary power.

Alex. Kempt, Chicago, manager of the Brush Co., has sold to the City of Duluth, Minn., two 60-light arc machines and 120 double carbon lamps.

The Chicago Arc Light and Power Co. will equip 40 of its circuits with the extremely ingenious device, recently invented by Mr. C. H. Rudd, of the Western Electric Co., for giving an alarm whenever a "ground" occurs on an electric light circuit.

The Marquette Electric Co., of Marquette, Mich., are putting in a pair of 40-inch twin Leffel improved turbine water wheels to develop 350 h. p. The manufacturers, Messrs. James Leffel & Co., Springfield, O., report a steady demand for their specialty.

The Troy Electric Light Co., Troy, N. Y., recently re-elected their former board of trustees, and the trustees elected A. E. Powers, president; George H. Morrison, vice-president; C. P. Kimball, secretary and treasurer, and Joseph A. Powers, superintendent.

The City of Chicago received bids for the supply of electric lighting apparatus for its public lighting stations on the — of September. The following tabulation of the bids is from the columns of the *Western Electrician*.

BIDS FOR THE CHICAGO CITY ELECTRIC LIGHT PLANTS.

The following is a tabulated list of the bids for lighting apparatus for the Chicago City electric light plants :—

Name of Bidders.	No. of lamps per dynamo.	Price of dynamo.	Total cost per lamp.	Price of lamp.	Average cost per lamp.	Cost of dynamos and lamps.	Amperes.	Volts.
Brush Electric Light Co.	20	$750.00	$37.50	$28.00	$65.50	$1,311.00	9.6	45
	30	985.00	32.83	28.00	60.83	1,825.00		
	65	1,750.00	26.91	30.00	56.91	3,700.00		
Charles H. Aldrich, W. E. system	30	750.00	25.00	25.00	50.00	1,500.00		
	35	775.00	22.14	25.00	47.14	1,650.00	18	28
	60	1,150.00	19.17	25.00	44.17	2,650.00		
Jenney Electric Co., Indianapolis, Ind.	35	1,050.00	30.00	34.25	64.25	2,248.75	21	22½
Thomson-Houston Electric Co.	50	1,845.00	36.90	36.00	72.90	3,645.00	10	45
	35	1,530.00	43.71	36.00	79.71	2,790.00		
Western Electric Co., Chas A. Brown, Manager	30	1,125.00	37.50	27.50	65.00	1,950.00	18	28
	35	1,225.00	35.00	27.50	62.50	2,187.50	18	28
	60	1,625.00	27.08	27.50	54.58	3,275.00	18	28
	30	855.00	28.50	27.50	56.00	1,680.00	10	50
	40	1,020.00	25.50	27.50	53.00	2,120.00	10	50
	60	1,350.00	22.50	27.50	50.00	3,000.00	10	50
Fort Wayne Electric Light Co.	40	1,540.00	38.50	37.50	76.00	3,040.00	9.6	45
	60	2,110.00	35.16	37.50	72.60	4,360.00	9.6	45
	30	900.00	30.00	30.00	60.00	1,800.00	22	30
Excelsior Electric Co.	30	990.00	33.00	31.50	64.50	1,935.00	9½ to 10	45 to 50
	50	1,550.00	31.00	31.50	62.50	3,125.00	9½ to 10	45 to 50

Lighting the Washington Navy Yard.—Judge Advocate General Remy, U. S. N., upon the recommendation of Commander Bradford, awarded the contract for equipping the Washington Navy Yard with an electric light plant to the Brush Electric Light Co., of Cleveland, at its bid of $13,975. The bid of the Schuyler Electric Co., of Middletown, Conn., was $13,750, but the engines it proposed to furnish were deemed inferior to those proposed by the Brush company.

The lighting of the new *Daily World* building now in course of erection, has been secured by the isolated lighting department of the Westinghouse Electric Co. The plant will be a large one, consisting of 3,600 lights, and will be one of the most complete ever installed.

THE commissioners of the District of Columbia have signed a contract with the Electric Light, Heat and Power Co., of Washington, operating under the Westinghouse Electric Co., of Pittsburgh, to light certain streets with incandescent lights. This was done in spite of the opposition of the Washington Gas Light Co. and the United States Electric Light Co., which claim a monopoly of street lighting for the district. All three companies will probably appeal to Congress.

THE HEISLER ELECTRIC LIGHT CO., of St. Louis, report a gratifying increase in their business. They are furnishing a plant of 300 30-c. p. lights to the Standard Light and Power Manufacturing Co., Montpelier, Vt. These lights are to be rented at a distance of four miles from the station. They are furnishing a plant of the same capacity to Frank Filer, Ludington, Mich., where arc lights have been operated exclusively heretofore. Another plant goes to the Globe Furniture Co., Northville, Mich., for public and commercial lighting. An extensive plant is being prepared for the North Broad Street Farmer's Market Building, in Philadelphia, and will be in operation at an early day. Another extensive plant is nearly ready for shipment to Henry Joel and Co., Finsbury, London, E. C., England, being the first Heisler installation in England. The Heisler stations at Hackettstown, N. J. and Matteawan, N. Y., have placed orders for increase in capacity, the order from the latter being for their fourth Heisler dynamo. The Heisler display at the St. Louis exposition continues to attract general attention, and a similar display is now being prepared for the Texas state fair, to be held at Dallas from October 13th to the 27th. In both of these cases, a handsome rental is paid for the Heisler lights.

Foreign.

England.—A private letter from a well-known electrician, who has been granted the somewhat unusual privilege of inspecting the new Sardinia street station of the Metropolitan Electric Supply Co. in London, expresses the opinion that it is the finest piece of work of the kind in the world, both in its electrical and mechanical details. This station was designed by Thomas Spencer, engineer of the Marr Construction Co., and constructed under his immediate personal supervision. Its full capacity is 25,000 lights. The machinery and apparatus throughout is of American design and construction. Westinghouse dynamos, Westinghouse compound engines and Babcock and Wilcox boilers being used. The station is now substantially completed and is awaiting the completion of the outside work, which has been delayed by difficulties respecting rights of way.

MANUFACTURING AND TRADE NOTES.

THE EDISON LAMP CO., whose factory is at Harrison, N. J., has just issued a new and interesting catalogue of new designs and artistic incandescent lamps and fixtures.

THE ABENDROTH & ROOT MANUFACTURING CO., of New York, has just booked an order for eight of its sectional safety boilers, to be shipped to Yokahama, Japan. The company is erecting at Greenpoint an additional factory, 200 feet long by 175 wide.

THE C. & C. ELECTRIC MOTOR CO. are meeting with gratifying success in the introduction of their larger motors. The success of their small motors—within 1 h. p.—mostly 1/8 h. p. for fans, sewing machines, dentist pluggers and the like, encouraged them to enter the field with a line of larger machines, running as high as 15 h. p.

McINTIRE & Co., of Newark, N. J., manufacturers of patent electric connectors, are filling an order for the Edison Electric Light Co., of Spokane Falls, Washington Ter., for 5,500 connectors from No. 6 to No. 16 B. & S. gauge, copper and iron loops for electric street railways, underground connectors for work in New York, lightning arresters for the Omaha Telephone Co. and the Metropolitan Telephone & Telegraph Co., N. Y. Sales reported last month amounted to 60,000 connectors and 5,000 terminals.

THE SPRAGUE ELECTRIC RAILWAY & MOTOR CO. has begun the manufacture of a new 75 h. p. motor. This machine resembles in appearance the ordinary Sprague motor of smaller sizes. The first one of these motors manufactured was for the Kearney Paper Co., of Kearney, Neb., where about 120 h. p. of electric motors built by the Sprague company will be used for operating the mill. The current for driving these motors is generated by water power several miles away. The second of these motors has been built for a long-distance transmission power plant, which has been ordered of the Sprague company for South Africa. Other machines of the same size go to other parts of the world as a result of the large demand for motors of this size in long-distance power transmissions, mining work and general industries.

THE WESTINGHOUSE MACHINE COMPANY'S business grows still. During the past five years its buildings have been extended from the square in Pittsburgh originally occupied by the Westinghouse Air Brake Co., until they now cover two and one-half blocks of contiguous property. Machinery has been added (much of it quite recently) until now the limit has been reached and there is no space for more No additional property is available in the vicinity, and to keep pace with the increase of the business the company is erecting a three-story warehouse for finished engines, repairs, etc., which will be provided with steam hoists, overhead cranes, and all known appliances for the quick and economical handling of heavy weights. In addition to this the company is now taking on a complete new force of workmen, so that the establishment can be operated continuously, day and night.

The annual election of the company was held at the Westinghouse building, in Pittsburgh, on Tuesday, July 30th, 1889, and resulted as follows: *Directors*—George Westinghouse, Jr., H. H. Westinghouse, Ralph Bagaley, John Caldwell, David E. Jackman. *Officers*—George Westinghouse, Jr., president; Ralph Bagaley, vice president and manager; H. H. Westinghouse, consulting engineer; David E. Jackman, assistant secretary and treasurer; William A. Bole, superintendent.

Immediately after the annual meeting the directors met and declared a three (3) per cent. cash dividend.

A. L. IDE & SON, of Springfield, Ill., through W. B. Pearson, manager of their Chicago office, report the sale of sixteen engines and boilers of 125 h. p. each to the City of Chicago, to furnish power for the four electric light stations now in course of erection by the city. Mr. Pearson has been very successful in the management of the Chicago department of Messrs. Ide's business. Their engines have deservedly a high repute among electric light people.

THE ELECTRIC GAS-LIGHTING CO., 35 Arch street, Boston, Mass., not content with their success in the field indicated in their title, have branched out into the manufacture and supply of house signaling apparatus. A recent circular from them describes and illustrates a variety of bells, annunciators and the like for use in private and public buildings. They make a point of the excellence of their Victor box bell, and also direct special attention to their "Tirrell" gravity drop annunciator.

THE HILL CLUTCH WORKS, Cleveland, O., have opened an engineering office in the Cook Building, 146 Franklin street, corner of Congress, Boston, Mass., for the more convenient transaction of their growing eastern business.

MESSRS. SHARP AND KENT, engineers and electricians, 34 Victoria street, Westminster, London, kindly sent us a price list of their line of measuring instruments, voltmeters and ammeters; the voltmeters reading from .5 to 1,300 volts, and ranging from £3 10s. to £8 10s. in price; the ammeters reading from .5 to 1,000 amperes, and priced from £2 2s. to £9. Sharp and Kent say their "marine" type of instruments is largely used on street cars, omnibuses and steamships.

CHAS. A. SCHIEREN AND CO., of New York, manufacturers of oak leather belting and lace leather, will, on or about October 1, remove their Boston house from 86 Federal street to new quarters at 119 High street, where they have been fitting up one of the finest belting establishments in the east. They will keep a large stock of their standard and special grades of goods, in order to insure quick shipments. In addition to the office and salesroom, they are fitting up a large repair shop for all kinds of repair work at short notice.

MESSRS. ROBERT A. KEASBEY AND CO., 58 Warren street New York, call attention to the merits of their magnesia sectional coverings for steam pipes, boilers, etc. They claim the advantages of lightness, durability, incombustibility, and readiness of application and removal, and offer to warrant the coverings to be as good after five years' use as when first applied. They will take pleasure in furnishing special electric light references at any time.

FIRE AT THE WESTINGHOUSE ELECTRIC CO.'S WORKS.

Quite a serious fire occurred in the works of the Westinghouse Electric Co., at Garrison alley and Duquesne Way, Pittsburgh, on the night of September 27. The flames broke out at a late hour in the evening, but by the efforts of the firemen were confined mainly to the old building, a five-story brick edifice originally purchased from the Union Switch and Signal Co. The new building erected last year, which is nearly fireproof, sustained but little damage. The portion destroyed was occupied mainly by the motor and arc lighting department of the business, and for the storage of materials. The loss is estimated at about $100,000, which is understood to be fully covered by insurance. Very fortunately for the company's business, the departments devoted to the manufacture of dynamos, converters and incandescent lamps escaped almost without injury, so that the work, which just now is very heavy, will be but little interfered with.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Albany, N. Y.	W't'rvliet T'npike&R.R.Co.	15.5	16	Thomson-Houston.
Atlanta, Ga	Atl'nta & Edg'w'dSt.Ry.Co.	4.5	4	Thomson-Houston.
Allegheny, Pa	Obs'rvat'y Hill Pass.Ry.Co.	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co.	2	3	Thomson-Houston.
Ansonia, Conn.	Derby Horse Ry. Co.	4	1	Thomson-Houston.
Appleton, Wis.	Ap. Electric St. Ry. Co.	5.5	6	Van Depoele.
Asbury Park, N. J.	Seashore Electric Ry. Co.	4	20	Daft.
Asheville, N. C.	Asheville Street Railway	3.5	5	Sprague.
Atlantic City, N. J.	Pennsylvania R. R. Co.	6.5	16	Sprague.
Baltimore, Md.	Balt. Union Pass. Ry. Co.	2	4	Daft.
Bangor, Me.	Bangor Street Railway Co.	5	4	Thomson-Houston.
Bay Ridge, Md.	Bay Ridge Electric R. R.	2	2	Sprague.
Binghamton, N. Y.	Washington St., Asylum & Park R. R.	5	4	Sprague.
Boston, Mass	West End St. Ry. Co., Brookline Branch	11	23	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	31	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co.	4	4	Sprague.
Buffalo, N. Y.	Buffalo, St. Ry. Co.	2.5	4	Sprague.
Carbondale, Penn.	Carbondale and Jermyn Street Railway	1.5	3	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co.	1	3	Daft.
Cincinnati, O.	Cinc. & Inclined Plane Ry.	6	20	Sprague.
Cincinnati, O.	Colerain Ave. Ry. Co.	5	8	Thomson-Houston.
Chattanooga, Tenn.	Chat. Elec. St. Ry. Co.	5	6	Sprague.
Cleveland, Ohio	East Cleveland Railroad Co.	8	16	Sprague.
Cleveland, O.	Brooklyn St. Ry. Co.	18	10	Thomson-Houston.
Cleveland, O.	Collamer Line, East Cleveland, O.	3	8	Sprague.
Columbus, Ohio	Columbus Consolidated St. Railway Co.	2	2	Short.
Crescent Beach, Mass.	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenp'rt Cent. St. Ry. Co.	3.5	9	Sprague.
Danville, Va.	Danville St. C. Co.	2	4	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co.	9	12	Van Depoele.
Decatur, Ill	Citizen's Electric St. Ry.	5	4	Thomson-Houston.
Decatur, Ill	Decatur Electric St. Ry.	3	1	Nat.Elec.Tract.Co.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	10	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co.	4	2	Van Depoele.
Detroit, Mich.	Highland Park Ry. Co.	3.5	4	Fisher.
Easton, Pa.	Lafayette Traction Co.	1	2	Daft.
Eau Claire, Wis.	Eau Claire St. Ry.	5	6	Sprague.
Erie, Pa.	Erie City Pass. R. R. Co.	12	20	Sprague.
Fort Gratiot, Mich.	Gratiot Electric Railway	2	2	Van Depoele.
Harrisburg, Pa.	East Har'sb'rg Pass. Ry.Co.	7.5	10	Sprague.
Hartford, Conn.	Hartford and Wethersfield Horse Railroad Co.	3	4	Sprague.
Ithaca, N. Y.	Ithaca Street Railway Co.	1	2	Daft.
Jamaica, N. Y.	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind.	Lafayette Street Ry. Co.	3	9	Sprague.
Laredo, Texas	Laredo City R. R.	4	4	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co.	6	7	Van Depoele.
Los Angeles, Cal.	Los Angeles Elec. Ry. Co.	5	4	Daft.
Louisville, Ky.	Central Pass. R. R. Co.	10	10	Thomson-Houston.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)	1	1	Thomson-Houston.
Lynn, Mass.	Lynn & Boston R. R. Co. (Highland Line)	2	3	Thomson-Houston.
Lynn, Mass.	Lynn & Boston R. R. Co. (Nahant Line)	.8	1	Thomson-Houston.
Lynn, Mass.	L. & B. R. R. Myrtle St. Line	3	4	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Marlboro, Mass.	Marlboro St. Ry. Co.	3	2	Sprague.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn.	Meriden Horse R. R. Co.	5	12	Daft.
Nashville, Tenn.	McGavock & Mt. Vernon St. Ry.	3	6	Thomson Houston.
Newark, N. J.	Essex Co. Pass. Ry. Co.	2.5	4	Daft.
New York, N. Y.	N. Y. & Harlem (Fourth Avenue) R. R. Co.	18.5	10	Julien.
New Orleans, La.			1	Daft m'tr and Gibson st'ge battery.
Newport, R. I.	Newport St. Ry. Co.	4.5	6	Thomson-Houston.
Omaha, Neb.	Omaha & Council Bluffs Railway and Bridge Co.	2	24	Thomson-Houston.
Omaha, Neb.	Omaha Motor Ry. Co.	10	26	Thomson-Houston.
Omaha, Neb	Omaha Horse R. R.	10	20	Sprague.
Omaha, Neb.	Omaha &Co'ncil BluffsR.R.	4	2	Sprague.
Ottawa, Ill.	Ottawa Electric St. Ry. Co.	5	8	Thomson-Houston.
Plymouth, Mass.	Plym'th & Kingston Ry.Co.	4.5	3	Thomson-Houston.
Port Huron, Mich.	Port Huron Electric Ry.	4	6	Van Depoele.
Reading, Pa.	East Reading R. R. Co.	2	3	Sprague.
Revere, Mass	Revere Beach Ry. Co.	1	1	Thomson-Houston.
Revere, Mass. (Ex.)	Revere St. Ry. Co.	2.5	5	Thomson-Houston.
Richmond, Va.	The Richmond Union Pass. Railway Co.	13	46	Sprague.
Richmond, Ind.	Richmond St. Ry. Co.	4	6	Thomson-Houston.
Rochester, N. Y.	Rochester Electric Ry. Co.	7	9	Thomson-Houston.
Salt Lake, Utah	Salt Lake City R. R. Co.	6.5	10	Sprague.
Salem, Mass	Naumkeag Street Ry. Co.	2	6	Sprague.
San Diego, Cal.	San Diego Street Ry. Co.	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co.	10	6	Fischer.
Seattle, Wash. Ter.	Seattle Electric Railway and Power Co.	5	9	Thomson-Houston
St. Catherine's, Ont.	St.Catherine's, Merritton & Thorold Street Ry. Co.	7	10	Van Depoele.
St. Joseph, Mo.	St. Joe. Union Pass. Ry. Co.	6	12	Sprague.
St. Joseph, Mo.	Wyatt Park Railway Co.	10	17	Sprague.
St. Joseph, Mo.	Wyatt Park Ry. Co. (Northern Division)	4.5	9	Sprague.
St. Joseph, Mo.	People's R. R. Co.	10	20	Sprague.
St. Louis, Mo	Lindell Ave. R. R.	5¼	10	Sprague.
Scranton, Pa.	The People's Street Ry.	12	20	Sprague.
Scranton, Pa.	Scranton Suburban Ry. Co.	5	10	Thomson-Houston.
Scranton, Pa.	Nay Aug Cross-Town Ry.	1.5	3	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry.	2	4	Thomson-Houston.
Southington, Conn.	Southington & Plantsville Ry. Co.	2	2	Thomson-Houston.
Syracuse, N. Y.	Third Ward Ry. Co.	4	8	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co.	2.5	6	Sprague.
Stillwater, Minn.	Stillwater Electric St. Ry.	5	6	Sprague.

Electric Street Railways in America now in operation.—*Continued.*

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Topeka, Kan.	Topeka Rapid Transit Co.	17	30	Thomson-Houston.
Troy, N. Y.	Troy & Lansingburg Street R. R.	5	6	Sprague.
Washington, D. C.	Eckington & Soldiers'Home Electric Railway Co.	3	10	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co.	10	5	Thomson-Houston.
Wichita, Kan.	Riverside & Sub'ban Ry.Co.	9	6	Thomson-Houston.
Wichita, Kan.	Wichita & Suburban Ry.Co.	7.5	7	Sprague.
Wilkesbarre, Pa.	Wilkesbarre & Suburban Street Railway Co	3	7	Sprague.
Wilmington, Del.	Wilmington City Ry. Co.	3	4	Sprague.
Windsor, Ont.	Windsor Elec. St. Ry. Co	2	2	Van Depoele.

Total—Roads 103
" Miles 541
" Motor Cars 851

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Adrian, Mich.	Adrian Electric Railway.	3		Nat.Elec.Tract.Co.
Adrian, Mich	Adrian City Belt Line Elec. Ry. Co.	3	4	Rae.
Akron, O.	Akron Elec. Ry. Co	6	22	Sprague.
Atlanta, Ga.	Fulton Co. St. Ry. Co.	9	8	Thomson-Houston.
Attleboro, Mass.	No. Attleboro & Wrentham St. Ry. Co	8	5	Thomson Houston.
Americus, Ga.	Americus St. Ry. Co.	5.5	4	Thomson-Houston.
Auburn, N. Y.	Auburn Electric Ry. Co.	3	3	Thomson-Houston
Boston, Mass.	West End St. Ry. Co., City Line, Boylston & Beacon Streets	230	300	Thomson-Houston.
Cincinnati, O.	Cincinnati St. Ry. Co.	2.7	8	Thomson-Houston.
Chattanooga, Tenn.	Chattan'ga Elec. St. Ry.Co.		2	Thomson-Houston.
Cleveland, O.	B'way & Newb'ugh St. Ry.	10	16	Sprague.
Cleveland, O.	East Cleveland St. R. R., Prospect St Line	5	32	Sprague.
Dallas, Texas	Dallas Rapid Transit R. R.	3	2	Sprague.
Dallas, Texas	West Dallas St. R. R.	3	2	Sprague.
Detroit, Mich.	E. Detroit & Grosse Pointe Ry.	8		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit City Railway, Mack Street line	2		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit, Rouge River & Dearborn R. R.	1	1	Sprague.
Denver, Col.	University Park Ry. & Electric Co.	4	3	Thomson-Houston.
Denver, Col.	So. Denver Cable Co.	4	2	Sprague.
Dubuque, Ia.	Key City Electric Ry.	2	4	Sprague.
Elkhardt, Ind.	Citizens Street Railway	7		Nat.Elec.Tract.Co.
Fort Worth, Texas	Fort Worth City Ry. Co.	10		Nat.Elec.Tract.Co.
Fort Worth, Texas	FortWorth L'd & St. Ry.Co.	15		Nat.Elec.Tract.Co.
Huntington, W. Va.		3.5	2	Short.
Joliet, Ill	Joliet St. Ry.	3	4	Thomson-Houston.
Kansas City	No. East St. Ry. Co.	7	10	Thomson Houston.
Kansas City, Mo.	Vine St. Ry.	3	6	Thomson-Houston.
Kansas City, Mo.	Metropolitan St. Ry. Co	4.5	4	Thomson-Houston.
Long Island City, N.Y.	Long Island City & Newton Electric R. R.	3	2	Sprague.
Lynn, Mass.	Belt Line Ry. Co.	4.5	4	Thomson-Houston.
Moline, Ill.	Moline St. R. R.	3	2	Sprague.
Manchester, Va.	Richmond & Man. Ry. Co.	3.5	10	Sprague.
Minneapolis, Minn.	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Minneapolis, Minn.	Minneapolis St. Ry. Co.	8	10	Thomson-Houston.
Muskegon, Mich.		4.5	5	Short.
Nashville, Tenn.	Nashville St. R. R.	5	8	Sprague.
Newburyport, Mass.	Newburyport & Amesbury Horse Ry. Co.	6	2	Thomson-Houston.
Newton, Mass.	Newton St. Ry. Co.	8	10	Thomson-Houston.
New York, N. Y.	North & East River Ry. Co.	3	20	Bentley-Knight.
North Adams, Mass.	Hoosac Valley Street Ry.	5	6	Thomson-Houston.
Ontario, Cal.	Ontario & San Antonio Heights Ry. Co.	8	4	Daft.
Ottumwa, Ia.	Ottumwa St. Ry. Co.	5	4	Thomson-Houston.
Passaic, N. J.	Passaic St. Ry.	3	3	Thomson-Houston.
Peoria, Ill.	Central Ry. Co.	10	15	Thomson-Houston,
Piqua, O.	Piqua Electric R. R.	3.5	4	Sprague.
Pittsburgh, Pa.	Federal Street & Pleasant Valley R. R.	8¼	25	Sprague.
Pittsburgh, Pa.	Pittsburgh Suburban Rapid Transit Co.		3	Daft.
Pittsburgh, Pa	Squirrel Hill R. R.	3½	5	Sprague.
Pittsburgh, Pa.	Second Ave. Pass. Ry. Co.	10	10	Thomson-Houston.
Plattsmouth, Neb.	Plattsmouth Electric R R	2	2	Sprague.
Port Chester, N. Y.	P. C. & Rye B'ch St.Ry.Co.	3	5	Daft.
Portland, Oregon	Metropolitan R. R.	3	4	Sprague.
Portland, Ore.	Willamette Bridge Co.	1.5	5	Sprague.
Quincy, Mass.	Quincy St. Ry.	5	4	Thomson Houston.
Red Bank, N. J.	Red Bank & Seabright Ry.	5	8	Thomson-Houston.
Richmond, Va.	Richmond City Ry. Co.	7.5	50	Sprague.
St. Louis, Mo.	St. Louis Bridge Co.	2	4	Thomson-Houston.
St. Louis, Mo.		3	13	Short.
Salem, Mass	Naumkeag St. Ry.	3	6	Thomson Houston.
Sarat'ga Springs, N.Y.	Saratoga Electric Ry. Co.	2	4	Thomson-Houston.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Sandusky, Ohio	Sandusky Electric Ry.	6.75	6	Sprague.
Scranton, Pa.	Hillside Coal Co.	1	1	Thomson-Houston.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Daft.
Spokane Falls, W. T.	Ross Park St. Ry. Co.	7.50	6	Thomson-Houston.
Springfield, Mo.				Fisher.
Sterling, Ill	Union Electric R. R	6	7	Sprague.
Sunbury, Pa.	Sunbury& N'th'land Ry.Co.	3¼	3	Daft.
Tacoma, Wash. Ter.	Pacific Ave. St. R. R.	6	6	Sprague.
Tacoma, Wash. Ter.	Tacoma Ave. St. Ry. Co.	2	4	Sprague.
Toledo, O.	Toledo Electric Ry. Co.	3	2	Thomson-Houston.
Vancouver Island	Victoria Electric St. Ry.Co.	4	4	Thomson-Houston.
Washington, D. C.	Georget'wn, Tenalleytown St. Ry. Co	6	3	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & West Side R. R.	4	3	Sprague.
Worcester, Mass.	Worcester & Shrewsbury	2.7		Daft.
West Bay City, Mich.	WestBay City Elec. Ry.Co.	5	8	Sprague.

Total—Roads 76

Notes.

THE SPRAGUE COMPANY recently contracted to equip an electric railway in Florence, Italy, as noticed last month. The equipment ordered covers five miles of road and 12 motor cars—erroneously stated at seven miles and 10 cars in this column last month.

THE THOMSON-HOUSTON COMPANY have orders for additional equipment for roads already in operation, as follows:—Cleveland, O., 86 motors; Louisville, Ky., four motors; Cincinnati, O., eight motors; Danville, Va., two trucks, two motors; Washington, D. C., 14 motors; New York (Julien company), 20 motors; Seattle, W. T., four trucks, eight motors; Lynn, Mass., four motors; Kansas City, Mo., seven motors; Omaha, Neb., eight motors; Rochester, N. Y., four motors.

SOME dissatisfaction appears to exist in Richmond, Va., in relation to the electric street railway service. A few days since, Mayor Ellison invited the president of the Richmond Union Passenger Railway to meet in conference several members of the city government. President Pizzini, in reply to the mayor is represented to have said that his company had given the electric system 18 months trial, devoting every energy possible to make it a success, and that he was compelled to admit that it was a failure, and that the idea of replacing mule power by electricity had been abandoned. He said that the owners of the road intended to furnish fast and reliable traffic by putting on more horse cars. He further stated that during the exposition last year, the company burnt out 20 armatures in one day, at a cost of $200 a piece. No definite conclusion appears to have resulted from the conference.

THE WASHINGTON STREET, STATE ASYLUM & PARK ROAD of Binghamton, N. Y., formerly equipped with the Van Depoele system, and now operating a Sprague equipment, is regularly carrying a large number of passengers. The grades at the end of the line, where formerly it was necessary to use cables to supplement the electric power, are now surmounted by use of the Sprague electric motors, and the use of cables is discontinued. The present equipment is first-class in every respect, and includes two improved Sprague electric motors to each car. The number of cars operated is five on four miles of track.

THE SPRAGUE ELECTRIC RAILWAY & MOTOR CO. of New York, have closed a contract for equipping the Brooklyn & Jamaica Electric Railway with the latest type of motors. This road was one of the first installed in the country, and the electrical apparatus used there at present has become somewhat antiquated as compared with more recent electric railway appliances. The equipment of each car and of the power station, will be thoroughly overhauled, and Sprague improved motors and dynamos substituted for those at present in use.

IT is reported that an electric railway company has been organized with a large capital, to construct and operate a line between St. Paul and Minneapolis, Minn., and that the Thomson-Houston company will furnish the etectrical equipment.

AT a recent meeting of the Brunswick (Me.) Electric Street Railway Co., the following officers were chosen: President, Weston Thompson; secretary and treasurer, F. H. Wilson; directors, Weston Thompson, J. P. Winchell, A. F. Gerald, C. B. Story, F. C. Webb, William M. Pennell, F. H. Wilson, of Brunswick, and A. F. Gerald, of Fairfield. The capital stock is $25,000. The storage battery system will be used on the road, which is expected to be in operation by the middle of October.

PERSONAL MENTION.

Two appointments have just been announced which occasion general surprise. Professor F. B. Badt, some time of the Western Electric Co., of Chicago, has resigned his late position to become General Constructing Engineer of the united Edison companies. His head-quarters will be in Chicago. Professor Badt is one of the best known electrical engineers in Chicago. Until within a year he was connected with the Chicago office of the United States Electric Light Co. Subsequently he joined the Western Electric staff. He is one of the most active members of the Chicago Electric Club, and is at present chairman of the house committee. The position which he will occupy is said to carry with it the largest salary paid to any electrical engineer in the country. The second appointment is that of Charles D. Shain to a position with the Edison company in New York. Mr. Shain has been General District Agent of the Westinghouse company at Cincinnati. He was formerly connected with the Chicago office of the United States company, but received the appointment of general agent at Cincinnati when the Westinghouse company secured control of the United States interests. Mr. Shain is well known in Chicago, and he has many friends in the city. It may be stated that these changes are among the results following Mr. H. Ward Leonard's recent visit to Chicago.

SPRAGUE AGENTS' ASSOCIATION.

The associated agents of the Sprague Electric Railway and Motor Co. will hold their semi-annual convention at the Weddell House, Cleveland, O., on Tuesday, October 8. Much interesting comparison of results and views, with discussion of business methods, may be expected from the coming together of the men who stand between the manufacturers and users of motors—in direct relations with both—and who may reasonably be expected to know what is what in the sale and use of electric power apparatus.

LEGAL NOTES.

STORAGE BATTERY LITIGATION.

The Mutual Electric Manufacturing Co., of Graham street, Brooklyn, has been manufacturing storage batteries for some time; the Brooklyn Incandescent Electric Light Co. have used these batteries to illuminate the Brooklyn Library, and several other buildings. The Electrical Accumulator Co., of New York claiming that this manufacture and use of storage batteries was an infringement of two or more of their patents, have recently begun suit in the United States Courts, and Judge Lacombe, on August 28, granted a preliminary injunction, which will operate to stop further manufacture and use of infringing batteries in Brooklyn.

But little can be added to our legal notes at present. Judges, attorneys, experts and litigants have been enjoying, or at least trying to enjoy, their annual vacation, and are now just settling down in earnest for the work of the fall campaign. No decisions of importance have been made by the courts in electrical suits, although several important cases are in the hands of the judges, in which decisions may be expected at any time. We understand that a number of the most important suits now pending between the Edison, Thomson-Houston and Westinghouse interests, especially those which are looked upon as test cases, will be taken up immediately and actively prosecuted during the coming season. It is undoubtedly to the interest of all parties concerned that some of these questions should be determined at the earliest possible moment, and it is therefore unlikely that any unnecessary delay will be interposed on either side. By the end of October it is probable that the season's work will be fully laid out, and the proceedings under full headway.

LITERATURE.

Municipal Lighting. By FRED H. WHIPPLE, Detroit, Mich., 1889.

About a year since, Mr. Whipple published a small and apparently somewhat hastily prepared volume under the above title, which apparently was found to fill an existing want, as it met with a reception at the hands of the public which in all probability was a genuine surprise to the author. The cordial reception vouchsafed to his first volume, has led the author to rewrite and very much improve the work, which now appears in a second edition. A short history of the art of street illumination is followed by a statistical sketch of the growth of the electric lighting industry, embodying the valuable data compiled by Secretary Garratt, of the National Electric Light Association, in which it is pointed out that the advancement of electrical science must continually tend to increase the earning capacity of existing plants, and hence can only render more and more valuable all investments in well managed electric light and power stations. Taking up the subject of municipal illumination, the author shows that this may be effected in three principal ways—by arc lights on towers, by arc lights on low supports, and by incandescent lights. It is obviously true that the best system for adoption in any given town or city must depend largely upon the circumstances of the particular case. The tower system is undoubtedly the most economical, wherein which, the buildings are not too high, and the streets are broad and not too heavily shaded with trees. But it is clear that in most places the incandescent system is gradually gaining ground in consequence of its better capacity for effective distribution. The detailed estimates given of the net cost of furnishing the arc light under average conditions have been apparently worked out with much care, and the conclusion arrived at is, that arc lights of nominal 2,000 candle-power can be run at a little under three cents per hour; but, of course, this figure will be considerably greater or considerably less in proportion as the local conditions are less or more favorable. We entirely concur with Mr. Whipple in his opinion that the quality of the light depends quite as much on the steadiness of the engine as upon the electrical apparatus, and that it does not pay any better to try to manufacture electric light with poor machinery than to manufacture cotton cloth or flour in the same way. Good machinery well installed always furnishes reliable service and costs the least to maintain.

A chapter of advice to intending purchasers of electric light

plants contains many suggestions of value. The fact is pointed out that it is not possible, by any known system, to produce a continuous and satisfactory light of 2,000 nominal c. p. by the expenditure of much less than 1 h. p. of energy. The author does not attempt to decide between the conflicting opinions of the advocates of high-speed and low-speed engines, and, as we think, wisely, for, in fact, the results attained with either, under proper conditions of installation and management, are sufficiently satisfactory, so that the question may as well be left to settle itself, which it will do in due time. In many, if not in most instances, the decision will depend upon the particular conditions of the case, which vary with almost every plant. This chapter also contains detailed suggestions for drawing up a proper specification for an electric light plant, which appear to be well considered and judicious.

Following these the reader will find an exceedingly well written chapter discussing the question of the proper installation and operation of central stations, both arc and incandescent. It is not often that a greater amount of useful information is found in an equal number of pages. Indeed, this chapter might well be elaborated into a book by itself.

In connection with his remarks upon the control and inspection of electric installations, the author has given verbatim the rules of the New England Insurance Exchange and Boston Fire Underwriters' Union, adopted April 15, 1889, and also the regulations issued by the New York Board of Electrical Control. Two chapters are devoted to a discussion of the relative merits of high and low tension systems, and of continuous and alternating currents. A brief *resume* is given of the advantages and disadvantages of each, but the author has, and, in our opinion, wisely, refrained from expressing any decided opinion as to their relative merits, inasmuch, as the decision must in any event depend so largely upon circumstances, that it can be neither possible nor desirable to attempt to lay down a hard and fast rule in favor of one or the other.

The much mooted question whether central stations for municipal lighting should be owned by the municipalities themselves or by private companies, is discussed at considerable length. The conclusion of the author, in which he is certainly supported not only by the opinions of unprejudiced persons who are competent to judge, but by the actual results obtained in the majority of instances, is that the interests of business communities are not promoted by having the public lighting carried on by the municipality. Mr. Whipple presents the case fairly on both sides, and quotes in full his own paper read at the meeting of the National Electric Light Association in Chicago last February, while he supplements his observations and deductions by presenting the facts so far as he has been able to gather them. It appears that there are now 51 electric lighting plants in the United States and Canada owned wholly or in part by municipal corporations. Detailed statistical information as to the first cost, operating expenses and receipts per light, together with more or less other information is given, in respect to each of these plants individually. Mr. Whipple also sent a circular of inquiry to the proper officials of each of the cities and towns referred to, the answers to which are given in full. They are, perhaps, principally remarkable for the variety of opinions expressed, but as might have been anticipated, the "new broom sweeps clean," and the general consensus of opinion of the city officials, is that corporation lighting is decidedly the best plan. It is safe to say, that these opinions will be likely to undergo important modifications after an experience of two or three years.

A special chapter is devoted to the extremely important subject of the proper distribution of light, and while, as in the case of so many other things, it is difficult to lay down any rules of universal application, yet the suggestions and considerations presented by Mr. Whipple will materially aid in arriving at the best solution of the problem in any special locality.

Perhaps the most general useful feature of the entire work is a carefully compiled statement, showing in detail the price paid in each town and city in the United States and Dominion of Canada for municipal lighting by contract, in which the systems used, the number of lights, the hours of service, the names of the officials in charge, and much other information, is given, the data being brought down to as late as May 1st, 1889. As a matter of reference, such compilation of information from authentic sources is simply invaluable.

The latter portion of the book is devoted to a more or less descriptive account of the different "systems" of electric lighting, dynamos, lamps, etc., while the storage battery and the electric motor receive some attention. This portion of the work is of no great value, and is by no means up to the standard of the matter which precedes it. In fact, it is little more than a somewhat unskillful compilation of the statements and illustrations contained in the several manufacturers' catalogues. The most useful part of it is the information respecting the size and capacity of the different types of dynamo machines of the several makers; but the other information given is not sufficient to be of the slightest use in enabling a purchaser to make an intelligent choice between the somewhat bewildering array of rival machines, each claiming for some reason or other of more or less importance to be better than its competitors. These remarks apply with equal pertinence to the catalogue of steam engines and water wheels, which follows the description of the electric machinery. Three or four pages of useful information and figures on belting may be found in the last chapter.

The work is very handsomely printed, with generous margins on good paper, and it is bound with a tasteful and durable flexible cover. It will certainly have a large sale, and it well deserves to, containing, as it does, in authentic and handy form, a mass of information and statistics which can be found elsewhere, if at all, only with great difficulty.

One feature which deserves the highest commendation is the careful, thorough, and accurate manner in which the book has been indexed.

Evolution of the Electric Incandescent Lamp. By FRANKLIN LEONARD POPE, Elizabeth, N. J. *Henry Cook*, 1889., 8vo. cloth, 91 pp. Price $1.00.

IN this thin volume, Mr. Pope has brought together and arranged—with connecting and explanatory matter from his own pen—a body of records tending to throw light upon the chronology of the various important and decisive steps taken by the considerable number of inventors and investigators who have, through experiment and discovery, contributed to the production of the electric incandescent light as now in commercial use.

The task of preparing such a collection of historical material can have been no light one, even to a writer so familiar as the author of this book with the records of the courts and patent office, and with the literature of electricity.

From the invention of Grove, in 1840, published in 1845, and the patent of Starr, issued in the same year, up to the invention and perfection of the "Arch shaped illuminant of carbonized organic material"—which the author deems "the one essential feature which differentiates the modern and successful lamp from its unsuccessful predecessors"—the reader may trace the gradual approach step by step, of patient industry, talent, and sometimes genius, towards the achievement now so familiar through the every-day use of the electric light.

A chronological table precedes the introductory pages, and at the end of the book one finds, what, alas, one does not often enough find, a serviceable index.

Notes.

MESSRS. GEBBIE & CO., of Philadelphia, have in press and will soon publish a new and copyright translation of "Babylon Electrique," by A. Bleunard, under the title of "Babylon Electrified." This translation by Frank Linstow White, will have all the original illustrations by Montader, and be comprised in one handsome volume, 8vo., at a popular price. The book will doubtless prove of much interest to electricians and general readers as well.

IN THE POCKET REFERENCE BOOK of the Union Switch and Signal Co., a copy of which we have recently received, is to be found an example of a kind of circular which ought to be more generally issued by the manufacturers of apparatus and machines whose merits cannot be appreciated without detailed information concerning their construction and operation. While not too large for a good sized pocket, the manual contains 364 pages, compact with just the sort of information needed by railroad engineers concerning the signaling and interlocking devices manufactured by the company. The preface states that "we have endeavored to place before our patrons a brief but comprehensive Reference Book, capable of being conveniently carried about by those whose business requires a clear knowledge of the many parts entering into interlocking and signaling, and from which they can order any part, or parts thereof for repairs, alterations or additions as may be found necessary.

"We have also endeavored to give as much general information as we deemed consistent with the nature of the book, and thus enable those not thoroughly versed in interlocking to intelligently select from the various devices shown one adapted to their purpose."

The purpose thus indicated is amply carried out. In classification and arrangement every provision is made for the convenience of the reader; the descriptions are concise but full, and copiously illustrated by excellent cuts numbered and lettered for reference. The extent and variety of the apparatus made by the Union Switch and Signal Co. will no doubt surprise many readers of the Reference Book. The application of improved devices for safety in railroad service has made its way too slowly; but it is surely and steadily gaining ground, and no railway engineer or official can afford to ignore the existence of methods and apparatus of the kind produced by the Union Switch and Signal Co.

IN a paper recently read before the American Otological Society, Dr. Clarence Blake, of Boston, advanced the opinion that the influence of the use of the telephone on the hearing power must be injurious, because the extremely low intensity, as demonstrated by experiment, of the sounds to be caught from the telephone, compelled a strain of the ear which soon fatigued it, and made it especially liable to injury by the accidental sounds of

comparatively high intensity, which were constantly liable to be heard. Other physicians reported a number of cases of impaired hearing which they believe to have been caused by the continued use of the telephone.

OUR highly valued British contemporary, *Industries*, hitherto maintaining its principal offices at Manchester, has found it desirable to transfer its chief offices to London. Its head-quarters will henceforth be at No. 358 Strand, London, the former branch office at 22 Wellington street having been removed to the new address. The change is made with the view of dealing more conveniently with the proceedings of the leading technical institutions, and with current matters of technical interest in the London district. Branch offices will be maintained at Manchester and Glasgow at the present addresses. All important general correspondence should be forwarded to the new London address.

WE have received from Howard Challen, publisher, 150 Nassau street, New York, Challen's Engineer's Log Book of Daily Runs—for a year; and from Practical Publishing Co., 21 Park Row, New York, Engineer's Hourly Log Book, by Robert Grimshaw, M. E. Both are conveniently arranged for the habitual record of the details of supply and performance of steam plants, and are sure to be found useful to all owners or operators of steam engines who care to know—as all should—just what they are getting out of their power plant and out of their engineers and firemen. Mr. Grimshaw's book, as implied in its title, is arranged for hourly records, whilst Mr. Challen's provides only for daily entries. The value of such records, regularly made and based upon intelligent and accurate observations, can hardly be overestimated in these days of keen competition and small margins of profit. No manufacturer or other consumer of power can acquire a trustworthy estimate of the possible waste going on in his power outfit without the systematic observations of the daily or hourly service, for the recording of which the serviceable manuals under notice have been prepared. Mr. Challen also supplies, in pads—blanks for "Engineer's Daily Report"—prepared by the Municipal Electric Lighting Co., of Brooklyn, so arranged that the required data from any number of engines, up to six, can be conveniently recorded daily on a single small sheet. These blanks would seem to be particularly useful in electric light and power stations.

RECENT PUBLICATIONS.

A Dictionary of Electrical Words, Terms and Phrases, by Edwin J. Houston, A. M., Professor of Natural Philosophy and Physical Geography in the Central High School of Philadelphia; Professor of Physics in the Franklin Institute of Pennsylvania; Electrician of the International Electrical Exhibition etc. New York: *The W. J. Johnston Co.*, Ltd. Cloth, 640 and 18 pp.

The Voltaic Accumulator; an Elementary Treatise by Émile Reynier. Translated from the French by J. A. Berly, C. E., A. I. E. E., etc. London and New York: *E. & F. N. Spon.* 8vo. cloth, 202 pp., illustrated. Price $3.00.

Papers on Alternating Currents of Electricity, for the Use of Students and Engineers, by T. H. Blakesley, M. A., King's College, Cambridge; Member of the Physical Society of London, M. Inst., C. E. Second edition, enlarged. London: *Whittaker & Co.* New York: *D. Van Nostrand Company.* Crown 8vo, cloth, 129 pp.

Traite, Theorique et Pratique d'Electrochimie, par Donato Tommase, Docteur des Sciences. Paris: *E. Bernard & Cie.* 1er Fascicule. 8vo, paper, 240 pp.

Modern Views of Electricity, by Oliver J. Lodge, D. Sc., LL. D., F. R. S., Professor of Experimental Physics in University College, Liverpool (Nature Series). London and New York: *Macmillan & Co.*, 1889. Crown, 8vo, cloth, illustrated, 422 pp.

INVENTORS' RECORD.

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS

From August 20 to September 10, 1889 (inclusive).

Alarms and Signals:—*Thermostat*, A. M. Butz, 409,316, August 20. *Electric Signal-Receiving Instrument*, S. D. Field, 409,675. *Station-Box for Watchmen's Electric Time Detectors*, J. E. Richards, 409,735. *Thermometric Indicator*, M. Meyer, 409,996, August 27. *Electric Gong*, J. H. Phalan, 410,189. *Signal*, W. H. Donner, 410,270. *Fire-Alarm System*, W. L. Denio, 410,318. *Signal for Mills*, W. H. Donner, 410,502, September 3. *Burglar Alarm*, E. M. Carhart, 410,683, September 10.

Clocks:—*Electric Pendulum Clock*, A. L. Parcelle, 410,013, August 27.

Conductors, Insulators and Conduits:—*Conductor for Conveying Electricity*, S. Z. DeFerranti, 409,181. *Joint for Electric Mains*, same, 409,183. *Pipe Casing or Conduit*, A. and E. L. Wyckoff, 409,235, August 20. *Electric Conduit*, H. A. Chase, 410,150. *Pipe-Coupling*, F. C. Rockwell, 410,293. *Apparatus for Applying Sheaths to Electrical Conductors*, C. Q. Goodwin, 410,410, September 3. *Insulator*, W. M. Davis, 410,637. *Air-Tight Covering for Electric Cables*, D. Brooks, Jr., 410,953, September 10.

Distribution:—*Distribution of Electrical Energy*, S. Z. DeFerranti, 409,182. *System of Electrical Distribution*, C. S. Bradley, 409,449 and 409,450. *Distribution of Electrical Energy*, S. Z. DeFerranti, 409,565 and 409,566, August 20. *Reactive and Induction Coil*, E. Thomson and E. W. Rice, Jr., 410,468, September 3.

Dynamos and Motors:—*Dynamo-Electric Machines*, S. Z. DeFerranti, 409,349. *Armature-Core for Dynamos*, D. Higham, 409,463. *Brush-Holder for Dynamos*, J. M. McClellan, 409,646, August 20. *Regulation of Coupled Dynamos*, O. P. Loomis, 410,170. *Commutator-Brush*, F. O. Blackwell, 410,265, September 3. *Armature*, J. R. Johnson, 410,592. *Method of Determining the Shape of Pole-Pieces for Dynamos*, J. G. Statter, 410,656. *Regulator for Dynamo-Electric Machines*, J. M. Bradford, 410,663. *Brush-Holder for Dynamo-Electric Machines*, C. D. Jenney, 410,670. *Commutator-Brush for Dynamo-Electric Machines or Motors*, R. Hoffmann, 410,896. *Magneto-Electric Machine*, A. S. Fitch, 410,964. *Magneto-Electric Machine*, same, 410,965 and 410,966. *Dynamo-Electric Machine and Motor*, F. J. Patten, 410,987. *Method of Operating Electric Motors*, same, 410,988, September 10.

Galvanic Batteries:—*Galvanic Battery*, G. C. Ward, 409,259. *Process of Making Solution Compounds for Galvanic Batteries*, W. P. Kookogey, 409,291. *Gas-Battery*, L. Mond and C. Langer, 409,365. *Process of Obtaining Electricity from Gas Batteries*, same, 409,366, August 20.

Lamps and Appurtenances:—*Arc Lamp*, R. D. Carson, 409,390. *Kiln for the Manufacture of Carbons*, P. P. Nungesser, 409,489. *Method of Manufacturing Carbons*, same, 409,490. *Combined Gas and Electric Light Fixture*, T. J. Pierce, 409,498, August 20. *Bracket for Electric Lamps*, J. S. Merrill, 409,852. *Shade or Globe Holder*, B. L. Coe, 409,928. *Incandescent-Electric Lamp Socket*, J. W. Collier, 409,929, August 27. *Joint for Carbon Filaments*, H. Lemp, 410,168. *Electric Arc-Lamp*, R. L. Cohen, 410,493. *Mast-Arm*, W. H. O'Beirne, 410,559, September 3. *Structure for Supporting Lamps above Streets*, J. S. Adams, 410,626. *Electric Light Fixtures*, J. C. Hollings, 410,689, September 10.

Measurement:—*Electric Meter*, M. M. M. Slattery, 410,860, September 10.

Medical and Surgical:—*Electric Dental Instrument*, F. Vernette, 409,437. *Apparatus for Treating Animals by Electricity*, G. M. Lawrence, 409,470, August 20. *Electric Belt*, C. Everett, 409,673, August 27.

Metallurgical:—*Solution for use in Separating Metals from their Ores*, J. C. Wiswell, 410,228, September 3. *Magnetic Separator*, G. Conkling, 410,877, September 10.

Miscellaneous:—*Electric Valve*, M. C. Wheeler and A. M. Clark, 409,170. *Electrical Indicator*, E. R. Knowles, 409,207. *Automatic Electrical Fluid-Releaser*, B. S. Molyneux, 409,364. *Electrical Circuit-Closer for Water-Indicators*, F. M. Dunn, A. Petticord and J. H. King, 409,460. *Electrical Lock*, P. Schwenke, 409,508. *Safety-Fuse for Electric Conductors*, W. S. Bishop, 409,628, August 20. *Lightning Arrester*, H. Lemp, 409,689. *Induction Coil*, E. Thomson, 409,714. *Coin-Operated Induction-Coil*, J. H. Elferlng, 409,738. *Electric-Recording Gauge*, J. Wills, 409,891. *Electric Pen Holder*, W. C. Holmes, 409,968. *Influence Machine*, R. Voss, 410,058, August 27. *Electrically Controlled Elevators*, C. E. Ongley, 410,180, 410,182, 410,183 and 410,184. *Elevator*, R. C. Smith, 410,212. *Method of Neutralizing the Residual Magnetism in Electro-Magnets*, F. and O. Haenichen, 410,276. *Cut-Out*, L. F. Furlong, 410,545. *Ticket-Printing Machine*, J. A. and C. H. Milliken and E. D'Amour, 410,555, September 3. *Magnetic Body Wear*, G. A. Scott, 410,652. *Electric Registering Deep-Sea Sounder*, A. J. Cooper, 410,786. *Process of Separating Magnetic from Non-Magnetic Particles*, G. Conkling, 410,876. *Apparatus for Weighing and Putting up Package-Tea, &c.*, O. A. Gill, 410,886. *Diaphragm for Electrolytic Apparatus*, G. Kerner and J. Marx, 410,976, September 10.

Railways and Appliances:—*Electrical Railway System*, E. E. Ries, 409,237. *Trolley for Electric Railways*, J. G. and R. Dickson and P. Snyder, 409,603, August 20. *System of Electrical Distribution for Railways*, W. J. McElroy, 409,752. *Electric Railway Crossing*, E. E. Ries, 409,756. *Underground Conduit for Electric Railways*, same, 409,757. *Electric Railway*, S. Z. DeFerranti, 409,775. *Electrically-Propelled Vehicle*, R. N. Allen, 409,815. *Cable or Electric Street Railway*, L. M. Clement, 409,996, August 27. *Electric-Railway Plow*, F. O. Blackwell, 410,264. *Tubular Conductor for Electric Railways*, L. Daft, 410,498, September 3. *Electric Lighting of Railway Cars*, T. M. Foote, 410,586. *Electric and Cable Railway Cars*, S. A. Bemis, 410,871, September 10.

Secondary Batteries:—*Secondary Battery*, C. A. Faure, 409,178; C. S. Bradley, 409,448, August 20. *Secondary Battery Electrode*, J. F. McLaughlin, 410,007. *Electrode for Secondary Batteries*, F. H. Smith, 410,037. *Apparatus for Charging Secondary Batteries*, W. P. Kookogey, 410,111. *Electrode for Secondary Batteries*, C. H. Carter, 410,136, August 27. *Apparatus for Automatically Charging Secondary Batteries*, S. C. C. Currie, 410,153, September 3. *Secondary Batteries*, J. T. Van Gestel, 410,680, September 10.

Telephones and Appliances:—*Telephone Switch System*, C. C. Gould, 409,574, August 20. *Telephone Receiving Instrument*, R. D'Unger, 409,736. *Adjustable Elbow Rest for Telephones*, J. J. Wolf, 410,059, August 27. *Telegraphone*, M. Wheless, 410,305, September 3. *Acoustic Telephone*, L. V. Elliott, 410,791, September 10.

EXPIRING PATENTS.

Patents relating to Electricity which becomes Public Property in October, 1889.

Reported by F. B. Brock, *Patent Attorney*, 639 *F. street, Washington, D. C.*

Battery, H. Highton, 131,878; *Electrical Tool or Machine*, J. P. Tirrel, 132,118; *Fire Telegraph*, W. Gillett, 132,278; *Railway Car Telegraph*, R. K. Boyle, 132,434; *Perforating Telegraph*, T. A. Edison, 132,456; *Meters*, S. Gardiner, Jr., 132,569.

metal from which the attenuated conductor is made: practice will evolve all these collateral advantages.

We think we are not mistaken in saying, that but for this discovery, electric telegraphy never would have become a fact. We may suppose it to have been the discovery of Professor Gale. It may not have been so; it may have been the discovery of Professor Henry. But whoever discovered it, it is undoubtedly *the* great discovery in the art of communicating intelligence to a distance by electricity. We have given a more detailed account of it, in order to illustrate what we mean when we raise the question whether the claimed invention of Morse was ever successful. He may have made a telegraph that would record arbitrary signs, capable of being interpreted; but was it a success, or was it a failure? Did it ever go into use? What was the object of all the experiments made by him and others? Was it not to make an electric telegraph that could be successfully used by the public, and have a commercial value? Did he succeed in making such a telegraph or in finding out, until Gale told him, the principle upon which it could be made? We do not so read the evidence. In view of the most recent decisions, Gale, and not Morse, is the man to whom we are indebted for the art of transmitting telegraphic signals to a sufficient distance to be of any practical utility.

ELECTRIC LIGHT CONDUCTORS IN NEW YORK.

AT no time since the enactment by the legislature in 1884 of the Subway bill, ordaining that all electric wires in cities of the State of New York containing over 500,000 inhabitants should be "removed from the surface of all streets or avenues" before the first day of November, 1885, has there been so much agitation of the overhead wire problem as during the past month. The killing of several persons within a few weeks through contact with electric lighting wires and the subsequent tragic death of lineman Feeks in the presence of a crowd of citizens, aroused both excitement and indignation, causing much frantic discussion in the daily press, and well nigh demoralizing the Board of Electrical Control, including its *ex officio* member, the Mayor.

The gravity of the situation is not to be questioned. There is a far greater mileage of electric light wires overhead in this city than in 1884, and a very large part of it is nothing short of a disgrace to a city pretending to be civilized. For the most part the construction remains as bad in design and execution as it was five years ago, and the conductors still consist mainly of the atrocious "underwriters" wire, the execrable and dangerous qualities of which have been fully known for years; and all this notwithstanding the thorough-going rules and regulations for overhead lines, prepared a year ago by Dr. Wheeler, and adopted by the Board of Electrical Control. So far as we can learn nothing worth mention has been accomplished during the past year towards inaugurating and maintaining the "electrical law and order" which Dr. Wheeler sought to establish. This failure has apparently been due to the lack of power on the part of the Board of Electrical Control to enforce its regulations and to the indisposition of the lighting companies to incur the expense and trouble of putting their lines in sound condition.

At the meeting of the board, October 9, and through the initiative and insistence of Mayor Grant, the following resolution was adopted :—

Resolved, That notice be given to all companies operating and furnishing electric lights on overhead wires in the City of New York to discontinue the use of such overhead wires as are not properly insulated until such time as said wires shall be certified to by the expert of this board to be in proper condition.

Much electric lighting was consequently suspended for several days, but the lighting companies sought and obtained from the courts injunctions restraining the Mayor and the board from interference with their circuits. The injunctions have been sustained by the decision of Judge Andrews, who thinks the lighting companies should have reasonable time to put their conductors in a safe condition, and that if they fail to do so their lines should be suppressed as public nuisances. The companies are now replacing bad wires with good ones at such a rate as to clear out the available stocks of suitable wire in the hands of manufacturers and dealers in this vicinity; that is to say, they are now doing what they might have done any time these five years past (excepting perhaps during the ten months that Mayor Grant has been in office), and which, if done in good time, would have contributed more than anything else to avoid loss of life and public opprobrium.

Although the lighting companies have much to answer for, the underlying source of the disgraceful situation is to be found in the still unsolved problem of municipal government in the large cities of this country. No better result could reasonably have been expected in New York from entrusting a most difficult and complicated technical and engineering work to a body of men so obviously and grotesquely incompetent as the members of the Board of Electrical Control and its predecessor, the Subway Commission. Not only is their plan of subways inadequate and incomplete, but such as it is, the work now completed provides for not more than one-eighth of the electric lighting circuits at present in use.

It is quite clear that if the business of electric lighting is to go on in New York, a large portion of the necessary conductors must remain above ground for some years. If the lighting companies will diligently pursue the course—for which they now have opportunity—of making their overhead lines as sound and safe as the resources of electrical engineering render possible, they will not only serve both the public and themselves, but may demonstrate the proposition that overhead electric light lines are not intrinsically more dangerous to life and property than underground lines bunched in iron pipes.

THE recent purchase by the Thomson-Houston company, of the property and franchises of the Brush Electric Co., of Cleveland, was a transaction altogether unexpected in electrical circles. Financially, it is the most important operation which has taken place in the electric lighting business since the era of combination and consolidation set in. The Brush company was the oldest one in the field; it has been managed from the outset with unflagging energy, and for the most part with uncommon commercial sagacity, and as a natural consequence, has been eminently prosperous and successful. The Thomson-Houston company has certainly paid a long price for the property, but

ARTICLES.

SOME METHODS OF REGULATING ACCUMULATORS IN ELECTRIC LIGHTING.[1]

BY GEORGE B. PRESCOTT, JR.

IN preparing the following paper, the limited scope of which is indicated by its title, I have assumed that it is generally conceded that the modern electric accumulator is an apparatus capable of performing a peculiar but useful function in the art of electric lighting as now commercially practiced, and that it is free from inherent defects which would render it unsuitable for such application. Indeed, I am sure that every careful observer has noted in the somewhat slow evolution of the accumulator, that structural improvement and adaptation to practical requirements, which unquestionably show that it has come to stay; and will acknowledge that even as it exists to-day, the accumulator is a factor in electrical industry too important to be ignored by those who take a broad view of the situation.

It is not my intention to refer to those numerous successful applications of accumulators to the propulsion of small marine vessels and land vehicles, to car lighting and other minor work where the continuous generation of power from the combustion of fuel would be impracticable; neither can I fully discuss their characteristic actions under working conditions, within the limits of this paper. Nevertheless, before proceeding to the subject proper, I deem it incumbent to point out that the electrical accumulator, even in its more improved forms, is an apparatus having well defined limits of capacity, and that these limits cannot be habitually exceeded without endangering its effectiveness and impairing its durability. Generally speaking, the limits referred to, which vary with every type and size of cell, relate to the rate and quantity of charge and discharge, these factors being measured respectively in amperes and ampere hours.

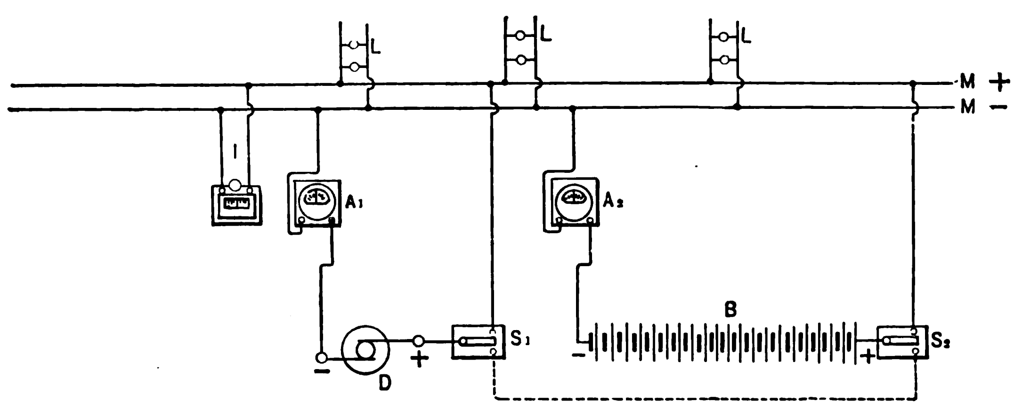


Fig. 1

In considering this admission, however, it should not be forgotten that every dynamo-electric machine is, to a certain extent, subject to similar limitations; for, like the accumulator, if it is demanded of them, they are capable of generating a current far exceeding their safe carrying capacity. Here the likeness ceases, however, for while the dynamo will deliver its normal current as long as adequate power is applied to its shaft; by continuing to draw current from an accumulator for too long a time, as likewise from an excessive rate and quantity of charge, serious damage may result. In fact in some respects an accumulator may be likened to a draught animal, which can be made to perform abnormally large amounts of work for short periods of time, but only at the expense of its vitality if the practice is frequent.

While much might be said regarding the maintenance of accumulators, and, moreover, the apparatus to be presently described is employed in a large measure for the purpose of effecting proper maintenance as well as regulation, it must suffice to say here that the normal working rate and capacity of an accumulator battery having been stated by the makers, all necessary data relating to its use may be ascertained from the indications of ordinary hydrometers, ammeters and voltmeters. That is to say, during the charge and discharge of such a battery the rise and fall of its potential and of the specific gravity of the electrolyte in its cells, are both quantitatively indicative of its condition and capacity for doing work. It is evident from what has already been said regarding the importance of working accumulators within certain prescribed limits, that in order to effect this result two classes of apparatus must be provided with every accumulator installation, viz.:—indicating or measuring instruments, and regulating appliances to be operated either automatically or by hand. I am constrained to add here that careful and extended observation leads me to believe that a lack of appreciation of these now obvious facts will largely account for the ill success attending many of the earlier accumulator installations.

Although there is reason for believing that some of the early promoters of business enterprises based on the manufacture of electrical accumulators, anticipated that accumulator systems of lighting were destined to compete with and perhaps supersede many direct systems, I believe that the more mature modern idea is that they are, for the present at least, mainly subsidiary to other electric lighting systems. As auxiliaries to many direct systems, accumulators undoubtedly effect a reduction in running expenses and add an element of reliability, besides accomplishing certain results that are not otherwise obtainable. In order to fully appreciate the truth of these statements, it will be necessary to glance at the conditions commonly existing in ordinary isolated and central station plants as they are operated at the present time. Doubtless every one who is familiar with the electric lighting business, is acquainted with the vagaries of the load curves during each 24 hours of a central station's run. Generally speaking, about sunset the load begins to increase gradually, finally reaches a maximum which is maintained for a greater or less period of time, and then falls to a minimum about which it fluctuates for the remainder of the 24 hours. Almost every isolated plant, whether it be in office building, hotel or apartment house, has a curve of the same general character; and probably most manufacturing establishments would prefer to have a few lights burning through the night, if only for the watchman's convenience, were it not for the expense entailed by the continuous operation of the plant. It is a truism to say that the cost of fuel per horse-power increases inversely as the power plant operates below its normal capacity, and that other operating expenses are, to a considerable extent, fixed independently of the load. In view of these facts it is universally acknowledged that the operation of large power plants of any character during periods of light loads, is enormously wasteful. Many have hoped that the supplying of current to small electric motors during the day would remedy the evil in lighting stations, and to some extent the expectation has been realized in manufacturing centres, but even here the unfortunate overlapping of the motor and lamp service still leaves an undesirable margin.

Here then is a field in which accumulators may perform their special function; not in competition with direct sys-

1. Paper read before the American Institute of Electrical Engineers, New York, October 29, 1889.

the character of the lighting. It is nevertheless true that they all show a remarkable similarity in the variation of current consumption, and all the 24 hour stations, particularly the smaller ones, require but a very small portion of the capacity of the plant for the greater part of the day. For this reason, many of the smaller stations cannot be profitably operated for more than 12 hours a day, and customers are therefore unable to obtain the light for the remainder of the 24 hours, the system being thereby deprived of much of its value to many consumers.

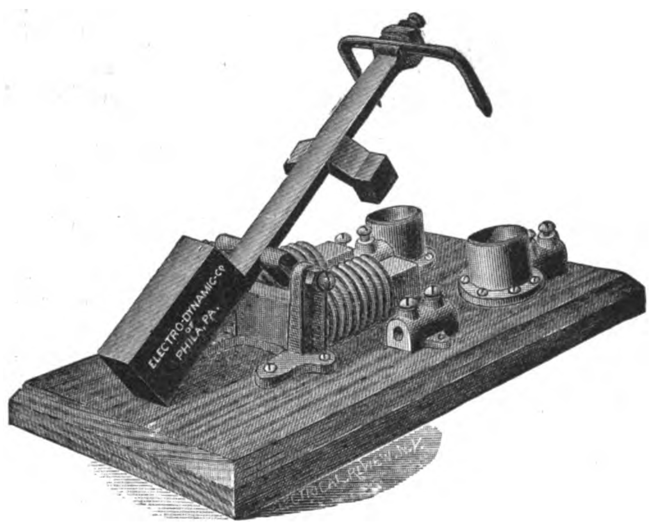


FIG. 4.

Here again the utility of the accumulator for tiding over these costly periods of light loads becomes apparent. It is evident that any ordinary station running for 12 hours a day, more or less, is not likely to have an output approaching its capacity for more than two hours at the longest, while for the greater part of the time it will be much below it. Why should not such a station be operated during that period of 12 hours at somewhere near its full capacity, and, therefore, under the most economical conditions for the power produced, and utilize the excess of current to charge a sufficient number of accumulators to maintain the lighter load during the remainder of the day?

This is the legitimate work of accumulators, and when they are properly installed and maintained to meet such conditions, the class of small stations referred to will be enabled to supply satisfactory light for 24 hours a day at moderate cost, while the larger stations may greatly reduce their running expenses and at the same time maintain the efficiency of their service.

Before proceeding to consider the methods of regulating accumulator currents, it will be advisable to examine some of the peculiarities of the element with which we have to deal. Generally speaking, the total current capacity, expressed in ampere-hours, of a single cell of accumulator of the lead lead-oxide type, is proportional to the number and size of its plates; its rate of discharge depending upon the number of plates and the effective surface of each, while the time of such discharge varies with their thickness. Although there are no obvious theoretical reasons why a single cell of accumulator should not be made sufficiently large to possess any desired capacity, there are mechanical considerations which make it advisable to limit the dimensions of a cell to the extent that it may be conveniently portable. Therefore when higher rates or longer discharges than an ordinary cell will give are demanded, two or more cells must be connected in parallel. On the other hand the electromotive force of all sizes of accumulators composed of the same elements is of course identical, but as the internal resistance of a cell varies with the number and surface of its plates, its effective working potential must be a function of the strength of the discharge current. As, however, the internal resistance of all sizes of accumulators is, in virtue of the large surface and compactness of their electrodes, exceedingly small in comparison with their rate of discharge, their working potential nearly equals their electromotive force on open circuit. While the normal effective working potential of a fully charged accumulator in good condition is usually stated as about two volts, as a matter of fact it is somewhat higher than this after being charged and rather lower after normal discharge, the average effective potential being about 1.95 volts. During the operation of charging an accumulator, its potential, or what is then usually called its counter electromotive force, rises gradually until the cell is nearly charged, and then more suddenly as gas is evolved, sometimes requiring an effective charging pressure of as high as 2.5 volts per cell if the current is continued after the cell is charged. In actual practice the accumulator is usually considered to be fully charged when the potential of the normal charging current reaches 2.3 volts per cell, or at 2.2 to 2.25 volts per cell when the charging rate is reduced as gas begins to be freely evolved towards the end. Similarly when a cell is discharged at the normal rate its effective potential falls during the progress of the discharge from 2 volts to 1.8 volts, at which latter point it is considered to be discharged to its normal limit.

The facts above cited to the effect that the electromotive force of accumulators rises during charge, and falls during discharge, and that their capacity for charge and discharge is limited, are the key notes to the regulative processes; and only one other point need be here considered. When two or more series of cells connected in parallel are to be charged at the same potential, it is evident that, unless each series is in precisely the same state in respect to residual charge, there will be a difference in their electromotive forces; and, in consequence, less current will flow in those series having higher potentials than others. While the larger current flowing into the less charged cells will have a tendency to bring up their potentials to the average, it is found in practice that some series will become fully charged sooner than others. The simple means provided for compensating for these variations will be duly described.

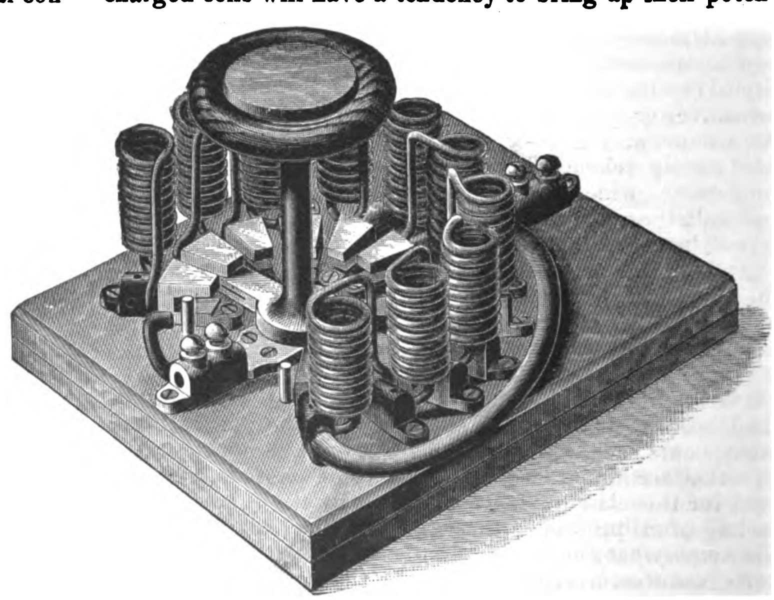


FIG. 5.

One of the commonest, and perhaps the simplest, applications of accumulators to lighting work is found in their employment in connection with direct isolated plants in

factories, office buildings, etc. In illustration of the method of applying accumulators in such cases, we may select as a type of this class of lighting one of those office buildings common in New York and other large cities. This building, we may assume, has already been, or is about to be, wired for 500 16-candle, 100-volt, ½-ampere lamps on the multiple arc plan, and is to be provided with a 125-volt, 200-ampere dynamo; it being calculated that more than 400 lamps will rarely be lighted simultaneously. We are not specially

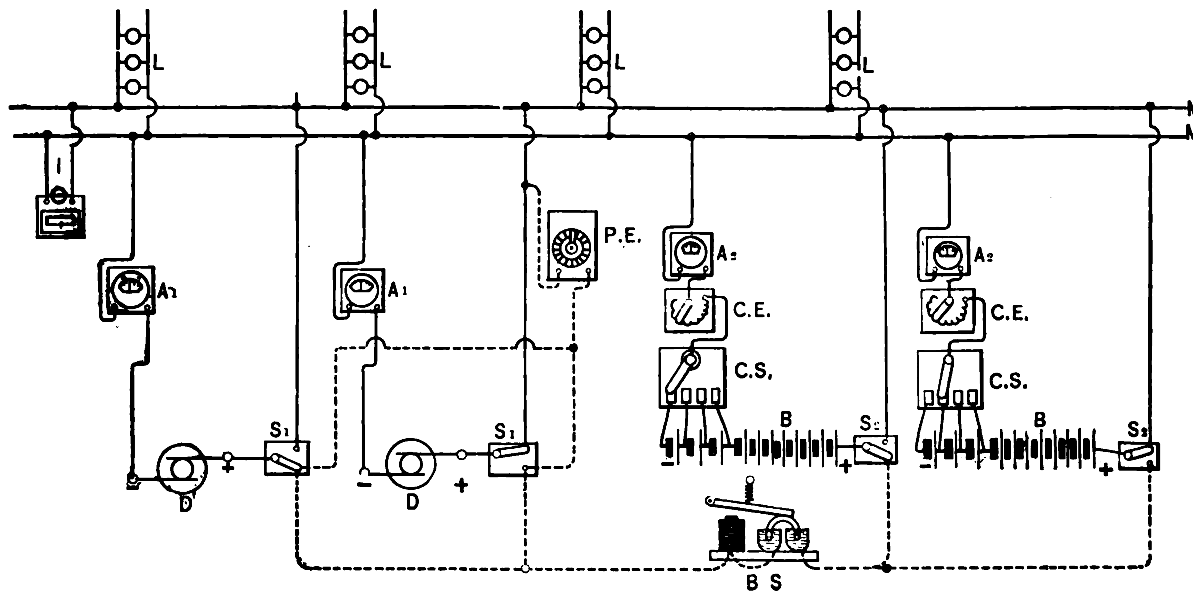


Fig. 6

concerned with the power plant, and will simply assume that it is of ample capacity, it being remembered that such buildings are usually steam heated, and therefore, offer favorable conditions for the operation of a plant of the character under consideration. Now it can be deduced from experience that, during the day, from say nine o'clock in the morning until about sunset, only a limited number of lights will be burned in certain dark corners of the building, and that as twilight and darkness come on the load will gradually increase, reaching a maximum at a

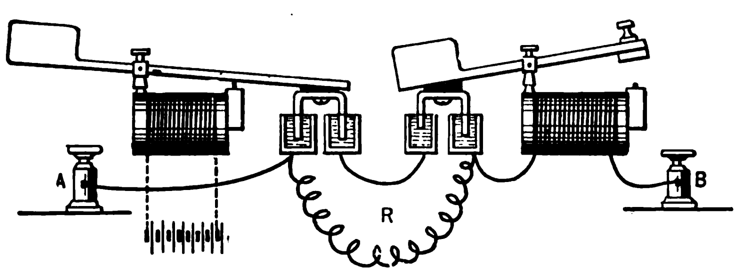


Fig. 7

certain hour depending upon the season; subsequently the load will decrease, finally reaching a minimum after the janitor and his assistants have finished their cleaning operations, which load will probably be maintained for the remainder of the 24 hours. It is evident that a direct plant operating under such conditions would necessitate the employment of two forces of men, either one or two in each, and would, moreover, be running under exceedingly uneconomical conditions for a large part of the time. Let us now consider in what manner accumulators may be added to this plant in order that it may supply the variable load for 24 hours daily, while at the same time dispensing with the services of one staff of men and reducing the running time of the engine to eight hours.

It has been shown in a general way how the load varies during 24 hours; but in order to ascertain the capacity of the accumulators required, it will be necessary to assume, though only approximately, somewhat more precise figures Say that the load is as follows:—

From 9 P. M. to 9 A. M., 20 lamps — 120 ampere-hours.
" 9 A. M. to 4 P. M., 200 " — 700 " "
" 4 P. M. to 6 P. M., 400 " — 400 " "
" 6 P. M. to 9 P. M., 50 " — 75 " "

An inspection of the above schedule shows that for 12 hours out of the 24 only 20 lamps, or 10 amperes, are used, while for three hours more only 50 lamps, or 25 amperes, are required; and a simple calculation proves that a set of accumulators having a capacity of 200 ampere-hours will be amply sufficient to maintain the light lamp load for 14 hours out of the 24. If the dynamo is started at 8 A. M. and operated until 6 P. M., while maintaining the required number of lamps during that period it will still have surplus current for charging the battery as follows:—

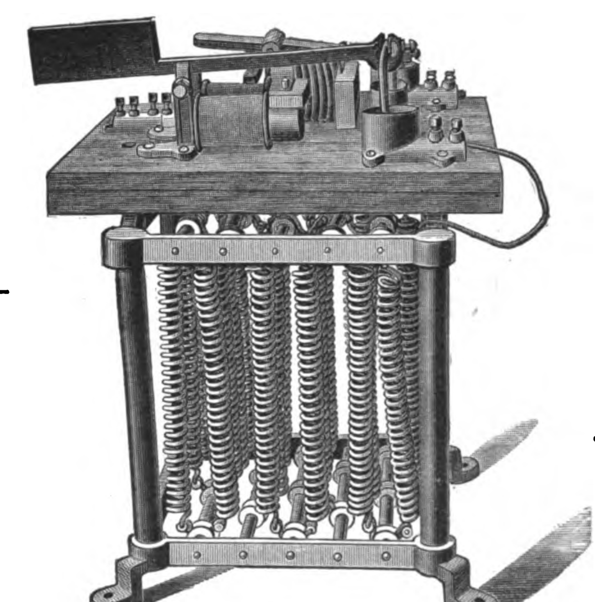


FIG. 8.

From 8 A. M. to 9 A. M., 190 amperes for 1 hour,
" 9 A. M. to 4 P. M., 100 " " 7 hours,

or 890 ampere-hours, an available capacity vastly in excess of the requirements. Now, if during the eight hours in which the dynamo is operating the accumulators are charged at the rate of 30 amperes, in that period they will receive a total charge of 240 ampere-hours. According to

the schedule, the maximum output required from the battery will be 185 ampere-hours, whence it follows that the charge received by it is more than ample, even after making the customary allowance of 20 per cent. for loss by conversion; and the desired result has been accomplished.

We have now to consider the details pertaining to the practical arrangements of such an installation. According to the stipulated schedule, after the dynamo ceases to run at 6 P. M., the battery alone must supply 25 amperes for three hours, and thereafter 10 amperes for 11 hours, or a total output of 185 ampere-hours. One series of 50 cells, having say a normal capacity of 30 amperes for eight hours, will satisfy these requirements, and will be well within the nominal rating of ordinary commercial cells. Assuming that these 50 cells, connected in series, have been

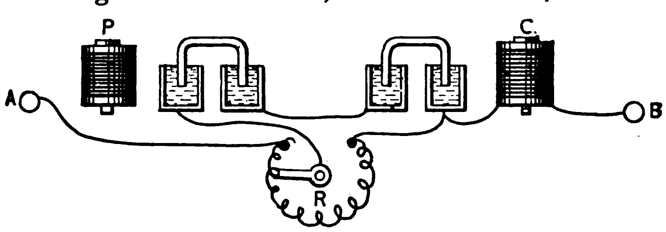


Fig. 9

suitably placed on insulated shelving at any convenient distance from the dynamo, they may be electrically connected with the latter and with the lamp circuit, as shown diagrammatically in figure 1.

In this diagram the two parallel wires M (+), and M (—), represent the common dynamo and lamp mains to which the pressure indicator, I, is permanently connected in the usual manner; and L L L represent the lamp circuits. The dynamo, D, is connected to the mains through the ammeter, A_1, on one side, and through the upper contact of the two-way switch, S_1, on the other. These are the ordinary connections of a multiple arc plant; and the (+) and (—) terminals of the accumulator battery, B, are also connected with the mains through the ammeter, A_2, and two-way switch, S_2, in precisely the same way. It is evident that if the levers of both switches, S_1, S_2, are against their upper contacts, the dynamo and battery will supply current to the lamp circuits in exactly the same manner as would two dynamos connected in parallel, provided, of course, that they are both at the same potential. On the other hand, if the potential of the dynamo slightly exceeds that of the battery, the current from the former will divide between the battery and the lamp circuit in a certain proportion determined by the ratio of the resistance of the lamp circuit to the internal resistance and counter electromotive force of the battery. If the levers of the two switches, S_1, S_2, are now moved to their lower contacts, the dynamo and battery will be connected in series with their like poles opposed, the main, M (—), acting as part of the circuit; and supposing that the pressure of the dynamo still exceeds that of the battery, the latter will receive a charge. Thus, by this very simple arrangement, the dynamo and the battery, either separately or together, may be connected with the lamp circuit, or with each other, or be entirely disconnected.

While this method satisfies all but one requirement in certain classes of plants where it is convenient to employ the dynamo solely for charging the battery during a part of the day, and to use either the dynamo or battery, or both, in the lamp circuits at other times, it does not, in fact, satisfactorily permit of that splitting of the dynamo current between the lamps and battery which was incidentally referred to. More than this: it fails to provide a means of compensating for that rise and fall of the potential of the battery during charge and discharge which has been mentioned; and this is the unsatisfied requirement referred to above. The reason why the dynamo cannot satisfactorily divide its current between the battery and lamps when connected in the manner illustrated in figure 1 has already been pointed out. During the charging of the battery its potential will rise to 2.2 volts per cell, so that the pressure of the dynamo must be raised to 110 volts in the case now being considered, and this excessive pressure would endanger the life of the lamps. How, then, will it be possible to employ the higher pressure demanded by the battery and at the same time supply current to a number of lower voltage lamps without raising their candle-power above normal? The answer is easily given, for it is only necessary to insert a suitable resistance in the main between the dynamo and lamp circuits in order to accomplish the

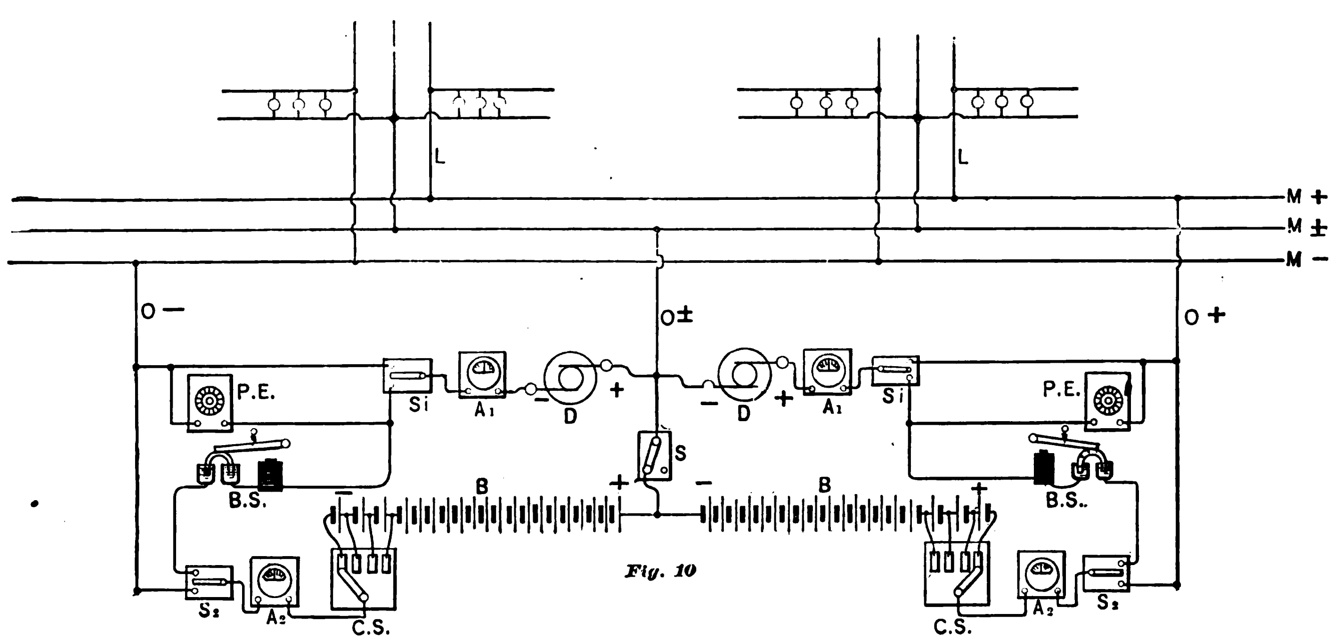


Fig. 10

desired result. Such a resistance, usually called a "pressure equalizer," should be made of wire sufficiently large to safely carry the current for the greatest number of lamps likely to be required at the time when the dynamo which supplies them is to be simultaneously called upon to charge the battery, and should be made conveniently adjustable, as the fall of potential through it varies with the current. The method of regulating the working potential of the battery is equally simple, for it merely consists in adding to, or subtracting from, the number of active cells in circuit.

This is accomplished by means of a multiple-point switch, called a cell-regulating switch, shown diagrammatically in figure 2, which is so constructed that, in the act of shifting the cells in and out of circuit, it neither interrupts the circuit nor short circuits the cells. It consists essentially of a single pivoted lever, which carries on its outer end a short metallic arm. This arm is attached to the lever by means of a block of insulating material, but is electrically connected with it by a short spiral of german-silver wire. The lever and arm may be made to pass over a number of

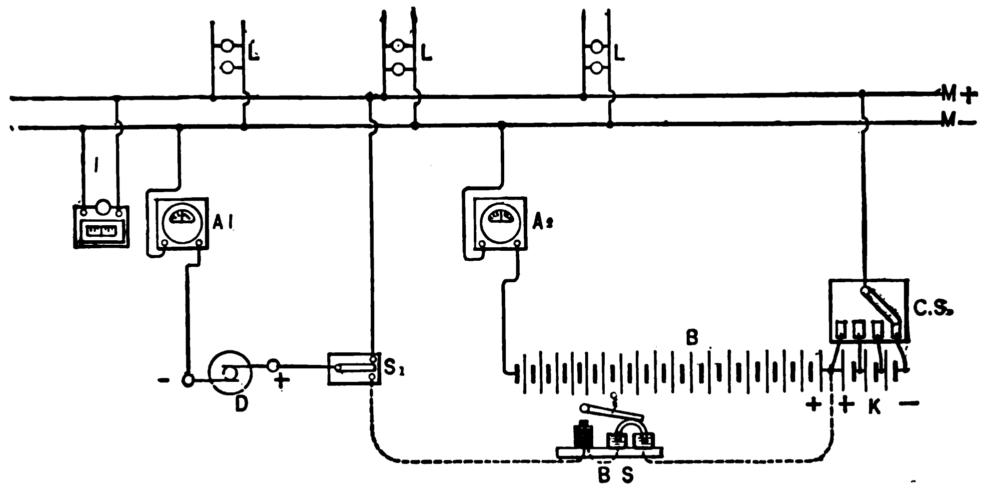


Fig. 11

contact strips, which are so arranged that, before the lever breaks contact at one strip, the arm comes in contact with the next strip, and the reverse action takes place when the lever is moved in the opposite direction. During the brief interval while both lever and bar are in contact with adjacent strips the cell connected to those strips discharges a feeble current through the spiral of wire.

It is necessary to mention here, that in practice it is customary to provide for the installation of 10 per cent. more cells in each series, than a simple calculation on the basis of two volts per cell would show to be necessary. Thus a plant using 100 volt lamps would require $100 \div 2 = 50$ cells + 10 per cent. of $50 = 5$, or 55 cells in each series. This allowance is usually sufficient to compensate for the fall of potential during discharge, as well as to provide for the ordinary loss of potential in the lamp mains.

The method of employing the pressure equalizer and cell-regulating switch is shown in figure 3, this diagram being otherwise similar to figure 1, with the further exception that an automatic break switch, B S, is inserted in the branch wire connecting the dynamo and battery through the lower contacts of the switches S_1, S_2. The function of the automatic break switch is merely to interrupt the charging current, in the event of the potential of the dynamo becoming so much reduced from any cause as to allow the battery to overcome it, and perhaps reverse its polarity. This switch, a practical form of which is shown in figure 4, consists of a simple electro-magnet with a weighted armature lever carrying at one end an ∩-shaped bent wire dipping into mercury cups. The charging current passes through this magnet and from one mercury cup to the other through the bent wire. When the current becomes greatly reduced to any predetermined extent, gravity overpowers the attractive force of the magnet, its armature is released and the bent wire being drawn out of the mercury cups the circuit is broken. By referring to the diagram in figure 3, it will be seen that the pressure equalizer, P E, has been so placed that when the switches S_1 S_2 are on their lower contacts, the current from the (+) pole of the dynamo will divide at switch S_1, part going through the battery and part through the pressure equalizer to the lamp circuits, both currents again uniting at the main, M(—), to return to the (—) pole of the dynamo. By this arrangement the potential of the dynamo may be adjusted to the requirements of the battery, and at the same time the pressure at the lamps suitably reduced by adjusting the resistance of the pressure equalizer.

When the proper balance is once obtained, and by means of this apparatus it may be quickly and easily accomplished by one man, no further attention than would ordinarily be given to the dynamo would be necessary, for although the counter potential of the battery would gradually rise toward the end of the charge and the current passing into the battery become correspondingly reduced, this result is even desirable, as it is somewhat advantageous to reduce the strength of the charging current as the battery becomes filled. In some installations, however, the extra or regulating cells are used to a more limited extent than the others, and thus having had less current taken from them they become sufficiently charged in a shorter time. A simple movement of the cell-regulating switch will then serve to cut out of circuit one or more of the charged cells as may be required, while the others receive current for a longer time. In some cases a further adjustment of the field rheostat of the dynamo and of the pressure equalizer may afterwards be required, and if so are quickly effected.

The first indication that the cells have received nearly enough charge will be given by the gentle evolution of gas which gradually increases thereafter, and which should never be allowed to become violent. At the same time the potential of the battery will approach 2.2 volts per

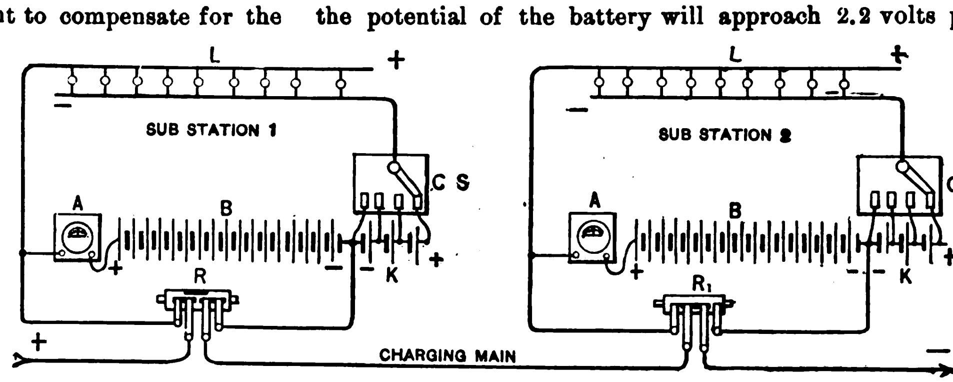


Fig. 12

cell, and even reach above 2.3 volts per cell when the gassing becomes marked. In order to take advantage of this indication of charge it will be sufficient to have a voltmeter conveniently located, and connected with the terminals of the battery, by means of which instrument, the number of cells in the battery being known, the potential per cell is readily ascertained. While this increase in potential is taking place, a similar variation in the density or specific gravity of the electrolyte in the cells also occurs, but this change, unlike that of the potential, remains fixed, even after the charging current is discontinued. That is to say, if the specific gravity of the liquid was 1.160 when the cells were normally discharged, it would rise to 1.190 when they were fully charged, and would remain at that

for a considerable length of time if no current was drawn from them. This rise of 0.030 in the specific gravity of the electrolyte is about the average increase in density which takes place in the common types and sizes of accumulators when 1.160 acid is used in the original charge, and when the range is from normal discharge to full charge. It often happens, however, that charging is commenced when the cells have more or less residual charge, and in this case the rise in specific gravity will be correspondingly less ; while on the other hand it will be correspondingly greater if the cells were previously over-discharged.

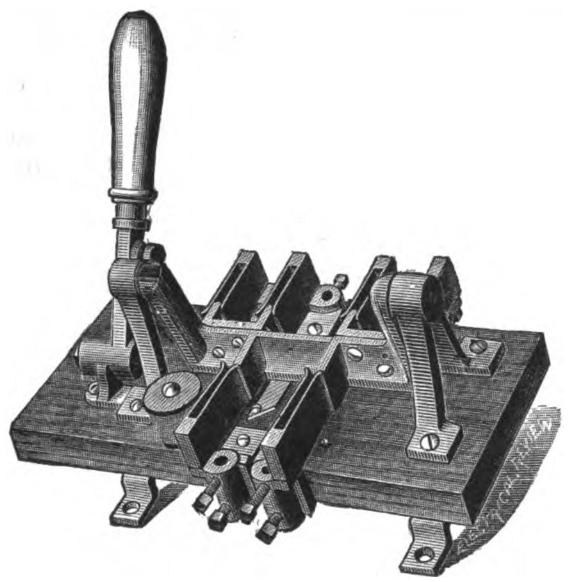


FIG. 13.

Again, if unusually large containing cells enclose the piles (as the aggregation of electrodes is commonly designated) the rise of specific gravity will be smaller, and on the other hand, larger if unusually small containing cells are employed. As heretofore stated, a similar drop in specific gravity and potential occurs when the cells are discharged, which in degree has about the same value as the rise. This variation in specific gravity is explained by the formation of lead sulphate during discharge, which implies the absorption of acid from the electrolyte, and by the reduction of this sulphate during the charge when the electrolyte is strengthened.

While the method of installing a single series of accumulators in connection with an isolated plant, as described and illustrated in figure 3, fulfills most of the conditions required in small plants operating a single dynamo ; in larger plants of a similar type using two or more dynamos, several series of the largest cells may be required. Although such an installation would consist mainly of an amplification of the system already described, still there exists a new difficulty not met with in that system. This arises from the fact already mentioned, that when several series of cells are charged in parallel, any essential difference in the amount of the residual charge in the several series, results in their allowing different amounts of current to flow through them, although all of the series are charged at the same potential. The remedy for this undesirable result is of the same character as that employed to prevent excessive pressure on the lamp circuits, when the dynamo which supplies them with current is at the same time used to charge accumulators. In circuit with each series of cells is placed a small adjustable resistance coil, called a current equalizer, a cheap practical form of which is shown in figure 5. It is composed of wire large enough to carry the maximum current of a single series of cells, and usually has a resistance of from $\frac{3}{10}$ to $\frac{6}{10}$ of an ohm. Each series of cells is also provided with an ammeter, and upon the commencement of a charge the current equalizers are so adjusted that each ammeter shows the same amount of current to be passing through each series. In order to avoid as much as possible any loss of energy in the current equalizers, they are all turned to the no-resistance point at the start, and resistance is then only inserted in such series as may be taking more current than others.

The general arrangement of an accumulator plant consisting of two dynamos and two sets of batteries is illustrated in figure 6, and a simple extension of this plan only is necessary to adapt any number of series of cells to a plant having any number of dynamos. It will be seen that one equalizer circuit, and one charging circuit with its automatic cut-out, are common to all the dynamos that may be used. While this arrangement possesses all the flexibility of the method of installing a single series of cells as shown in figure 3, it has the additional advantage that at such times as the load is below normal, a spare dynamo can be exclusively employed for charging the cells, and thus avoid loss of energy in the pressure equalizer. As a general thing when the current equalizers, C E, have once been adjusted at the beginning of a charge they need but little if any further attention, still if from any cause one series of cells should happen to be overdischarged, or discharged more than the remaining series, a suitable readjustment of the current equalizers will permit the undercharged series to receive current at a higher rate than the others, and thus equalize itself with the others. It may also be mentioned that both the pressure and current equalizers may be made to operate automatically by the application of a potential magnet to the former and of a current magnet to the latter, together with a simple but somewhat expensive train of gears to move their levers. This is found to be wholly unnecessary in practice, however, as an engineer is usually in constant charge of such a plant while the dynamos are running, and he can easily devote the little time necessary to the infrequent regulation required.

It was mentioned in the early part of this paper that it was possible to injure accumulators either by overdischarging them or working them at too high a rate. It is assumed that, in the larger plants, there will be such supervision available under ordinary working conditions that occurrences of this kind will be avoided ; but a simple device for preventing such abuse of the cells in smaller

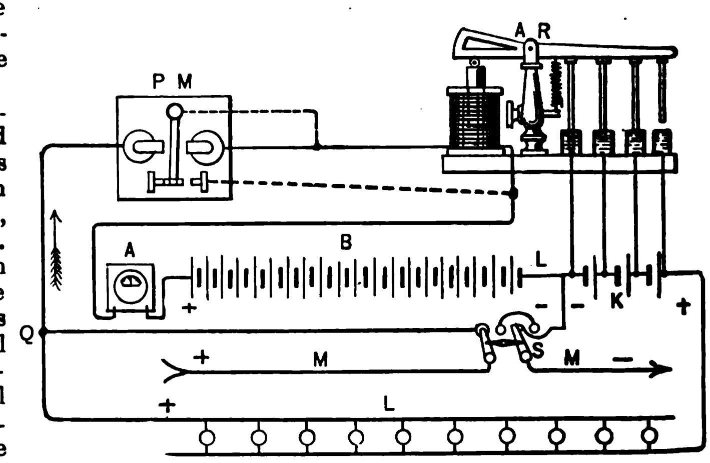


Fig. 14

plants, where such supervision is not always convenient, has been devised. It is called an overload and overdischarge switch, and its operation is based on the fact that, when a series of cells is overdischarged, their potential falls below a minimum value, and that when they are worked above their normal rate the current exceeds a maximum value. The apparatus consists essentially of a pressure magnet connected to the terminals of the battery, and of a current magnet in series with the battery ; when the potential of the battery falls below a minimum value, the armature of the potential magnet is released and throws

an artificial resistance into the battery circuit, and thus reduces the current; and similarly, when the current exceeds a maximum value, the armature of the current magnet is attracted and performs a similar function. The connections of this overload and overdischarge switch, O and P, are shown diagrammatically in figure 7, in which a

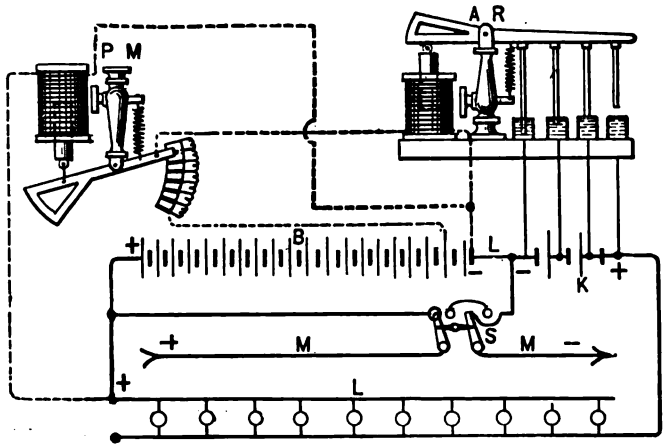


Fig. 15

common resistance, R, serves for either magnet. The battery current passes from A to B through the overload magnet, while the terminals of the overdischarge magnet are, as before stated, in shunt to the battery terminals. In figure 8 is illustrated a practical form of a combined overload and overdischarge switch.

With the object of reducing the cost of the regulating apparatus whenever both the combined overload and over-discharge switch and the current equalizer are to be used with the same series of cells, the switch portion of the equalizer may be mounted on the resistance frame; and thus a single resistance coil be made to do service for both instruments. This combination, of which the connections are shown in figure 9, while allowing the current equalizer switch to control the full range of resistance, at the same time causes the whole coil to be thrown into the battery circuit upon the operation of either the overload or over-discharge switch. This, of course, diminishes the brilliancy of the lamps, and thus indicates the state of affairs to those interested.

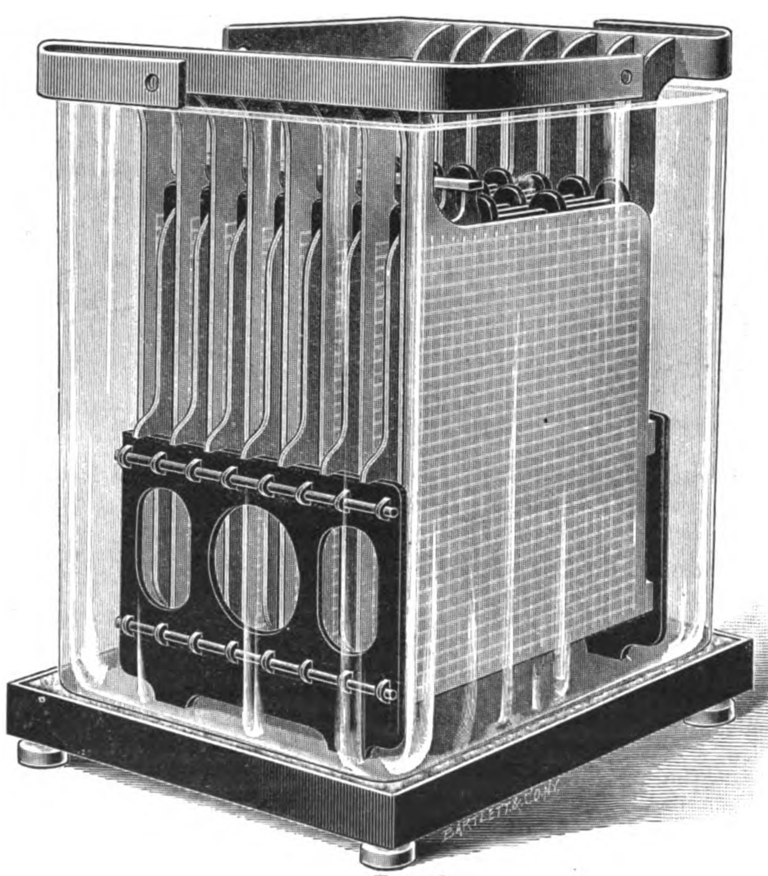


FIG. 16.

In applying accumulators to plants operated on the three-wire system, a simple extension of the method already described is adopted, except in the case of small stations requiring only one series of accumulators, and where the working circuits can be multiplied during the light load, so that the ordinary method will suffice. In larger plants the batteries are installed in pairs, each series having the same apparatus as before; and as this has already been fully explained, it will only be necessary to add that, in adapting two series of cells to the three-wire system, the two batteries are connected in series in the same manner that the dynamos are connected. The general plan of this arrangement is shown in figure 10, from which unimportant details have been omitted. At the top of this diagram the three horizontal lines M (+), M (±), and M (—) represent the omnibus wires in the dynamo room, from which the feeders, L, are led. The three vertical lines, O (+), O (±), and O (—), are extensions to the omnibus wires to which the dynamos are directly connected in the usual manner when the levers of the switches, S_1, are on their upper contacts. The batteries are also connected with the omnibus wires in a similar way, so that when the switches, S_2, are closed on their lower contacts the batteries will also discharge into the lamp circuits in parallel with the dynamos. Now, if the switches, S_1, are turned to their lower contacts, and the switches, S_2, to their upper contacts, the current from the dynamos will divide at the switches, S_1, part going into the lamp circuits, and part through the batteries, which thus receive a charge. As in the multiple arc system, the potential of the dynamos being assumed to be raised above the normal to meet the requirements of the batteries, in order to suitably reduce the pressure on the lamp circuits, it is only necessary to adjust the resistance of the pressure equalizer, P E. In central stations where the feeders are already provided with pressure equalizers the connections are still more simple, for the batteries are merely connected to the omnibus wires, while all other connections of the ordinary three-wire station are unchanged. In such cases, the increased pressure at which the dynamos are operated during the time the batteries are charging is reduced at the lamps to the proper point by the usual adjustment of the feeder or pressure equalizers. During the charging period all regulation of the accumulators may be dispensed with by opening the switch S_1, when both batteries will be connected in a single series to the full pressure of both dynamos. In addition to the apparatus shown in the diagram, each series of cells is provided with a double plug switch and sockets suitably disposed, by means of which the relative positions of the batteries on the two sides of the system may be changed by simply transposing the plugs from one socket to the other. The object of this arrangement is to provide means for compensating for the unequal discharge of the batteries when the two sides of the lamp system are unbalanced; and the transposition is never made oftener than once each day. In all other respects the manipulation of accumulators when applied to three-wire systems is practically the same as when they are operated on the multiple arc plan. To increase the accumulator capacity of three-wire stations,

double batteries are added in parallel to the first set, just as additional dynamos would be.

It was explained further back that the extra, or regulating cells, in each series often became charged sooner than the remainder of the cells, and required to be removed from the circuit before the others. This operation, of course, calls for some labor; and, little as it is, it would still be desirable to have the number of cells in a series remain fixed both during charge and discharge. By the use of what are called counter electromotive force cells, this result may be effected, and at the same time the pressure equalizer be dispensed with. These very simple cells are made like an ordinary Planté accumulator of plain sheets of an inoxidizible lead alloy and without active material. When a current is passed through them they act as gas voltameters, and while they instantly oppose a counter electromotive force of about two volts, they are incapable of producing a current of any appreciable amount or duration on account of their inoxidizable property. The use of counter electromotive force cells in place of equalizers is advantageous in several ways, for not only may their internal resistance be made so small as to be practically negligible, but their counter electromotive force is as effectual in reducing excessive pressure as a dead wire resistance, while possessing the unequaled advantage that the fall in potential of the current passing through them is unaffected by any variation in the strength of such current.

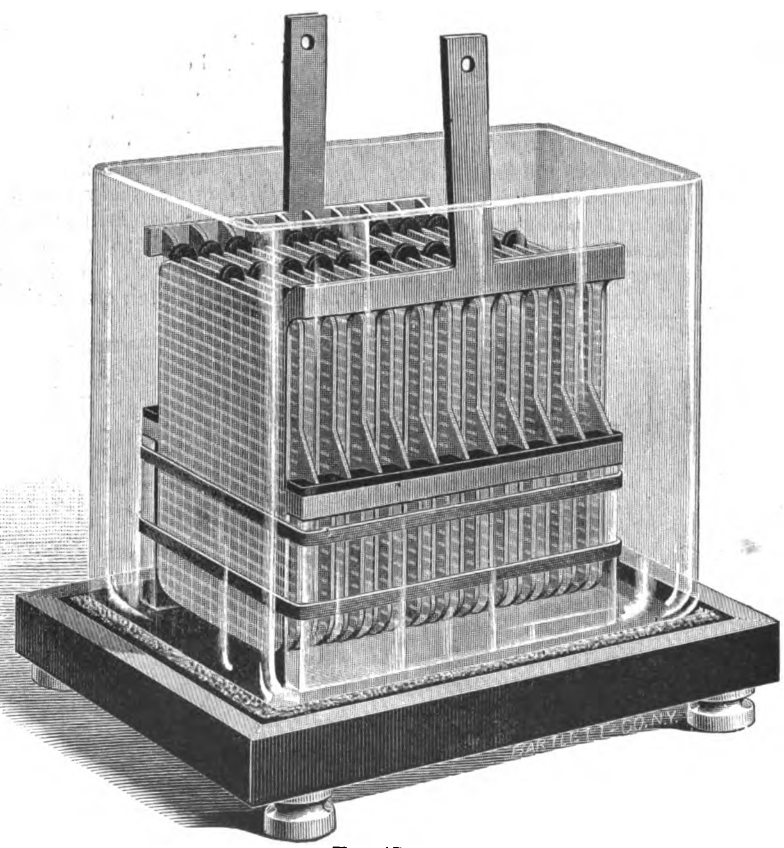


FIG. 17.

The method of using these counter electromotive force cells is shown in figure 11, which represents a single series of accumulators installed in connection with a direct lighting plant operating one dynamo, as first described, and for simplicity and effectiveness this method cannot be well exceeded. The dynamo is connected to the lamp mains, as before, through an ammeter on one side, and through the upper contact of a two-way switch, S, on the other; while the battery, B, is similarly connected to the lamp mains on one side, but on the other the circuit is completed through several counter electromotive force cells, K_1, the number opposed being governed by the position of the cell regulating switch, C S. When the lever of switch S is on its lower contact, the charging circuit is completed in the now familiar manner. The action of a plant arranged in the above way is as follows:—assuming the lever of the cell-regulating switch to be turned off, or open, as the expression goes, and that the dynamo switch is on its upper contact, the dynamo alone supplies current to the lamp circuits. If, now, the lever of the cell-regulating switch is turned to its left hand contact plate, the battery will be similarly supplying current to the lamp circuits in conjunction with the dynamo, or alone if the dynamo switch is opened. If the dynamo switch is now turned to its lower contact, the dynamo current will divide at the point where it connects between the battery and counter electromotive force cells, part going through the battery and back to the dynamo through the (—) lamp main, while the remainder will pass through the counter electromotive force cells to the lamps. Thus, while the full pressure of the dynamo current will be effective at the battery terminals, its pressure at the lamps will be less by 2, 4, 6, etc., volts, according as 1, 2, 3, etc., counter electromotive force cells are opposed to the passage of the current into the lamps by the position of the lever of the cell-regulating switch.

When the battery has been fully charged and it is desired to stop the dynamo, the latter may be disconnected by opening the switch S_1, when the battery alone will maintain the lamps. As previously explained, the potential of the battery will be a maximum immediately after it has received a charge, so that in this case if the battery has the usual allowance of extra cells its potential will be higher than the lamps require. More or less of the counter E. M. F. cells may now be inserted in the lamp circuit, however, until the potential is suitably adjusted. Although during the greater part of the discharge the E. M. F. of the battery will remain fairly constant, if discharged to its limit the potential will slowly fall towards the end, and this fall must be compensated for by removing one or more of the counter E. M. F. cells from the lamp circuit.

It is to be noted that by means of the above method, the number of cells in the battery proper is fixed and unalterable during both the charge and discharge, and that whenever the dynamo is supplying current to the lamps, its surplus current is always available for charging the battery; moreover, only one adjustment of the counter E. M. F. regulating cells opposed to the lamp current will be required. It is obvious that counter E. M. F. cells may be substituted with equal effectiveness for the equalizers and regulating cells employed in all of the previously described systems, and it seems unnecessary to go into any further particulars in order to illustrate the practicability of such systems when properly installed and operated.

We have now to consider another branch of the electric lighting business, in which accumulators also claim a share of attention, viz.:—the supplying of current to lamps located at a considerable distance from the source of power.

The first method to be considered, is known as the half direct plan, in which one or more series of cells are installed in any number of sub-stations conveniently located near centres of lamp consumption. The charging station may be situated wherever economy dictates, without any special reference to the location of the batteries, for although the expense of the charging wire and the cost of the energy wasted in it, cannot be neglected, both these factors must be offset by the saving effected from locating

action of the solenoid magnet causes one or more counter electromotive force cells to be inserted in the lamp circuit in such a way as to oppose their electromotive force to that of the charging current, while the full pressure of this current is available at the battery terminals. If now the number of lamps is increased to such an extent that not only all of the charging current passes through them, but also that more or less current from the battery joins in parallel with it; then the current from the battery will traverse the polarized magnet in the opposite direction from that previously taken by the charging current, and its armature will be moved against its right hand contact, thus short circuiting the solenoid magnet and the counter electromotive force cells, as indicated by the broken line. For, as the sketch shows, the lever of the solenoid magnet is so balanced that when no current is traversing the magnet, its metallic contact rods all dip into their respective mercury cups, and so shunt around the counter electromotive force cells with which the latter are in electrical connection. When the lamp load becomes reduced and the charging current is discontinued either by the stoppage of the dynamo, or by its being shunted past that particular battery by a movement of the switch s to the right, the battery alone works into the lamp circuit, and the counter electromotive force cells are short circuited.

While the automatic regulator just described, when applied to the half direct system, maintains the pressure at the lamps sufficiently uniform for practical purposes, whether the charging dynamo is operating or not, and although the proximity of the battery to the lamps it supplies prevents undue variation of potential when the load changes; yet a perfectly automatic method of maintaining a constant potential at the lamp circuits, even where the resistance of the leads is great, would be generally useful. Such a method is illustrated in figure 15, in which the battery, counter electromotive force cells, lamps and charging circuits occupy the same relative positions as before. The solenoid magnet of the regulator is no longer in series with the battery, however, and is, in fact, entirely disconnected from it, while the polarized magnet is replaced by a

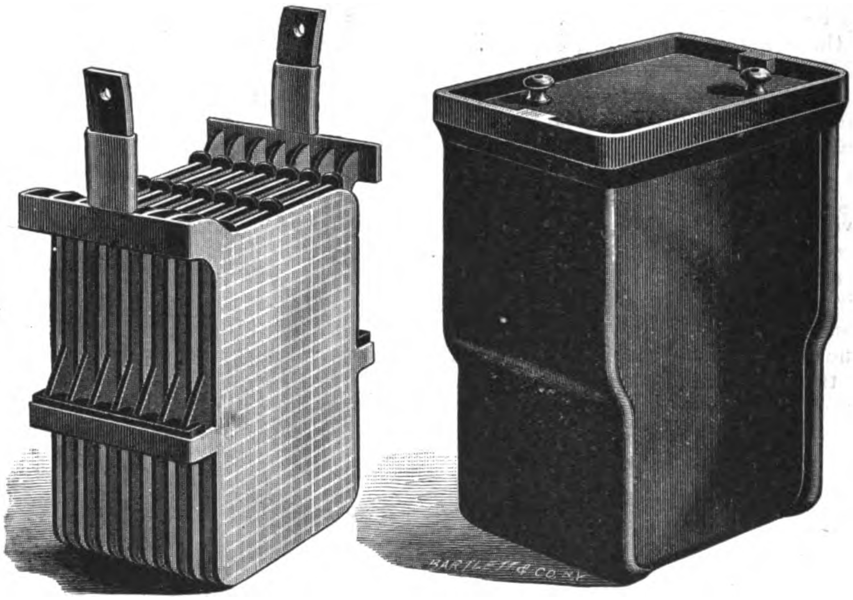


FIG. 19.

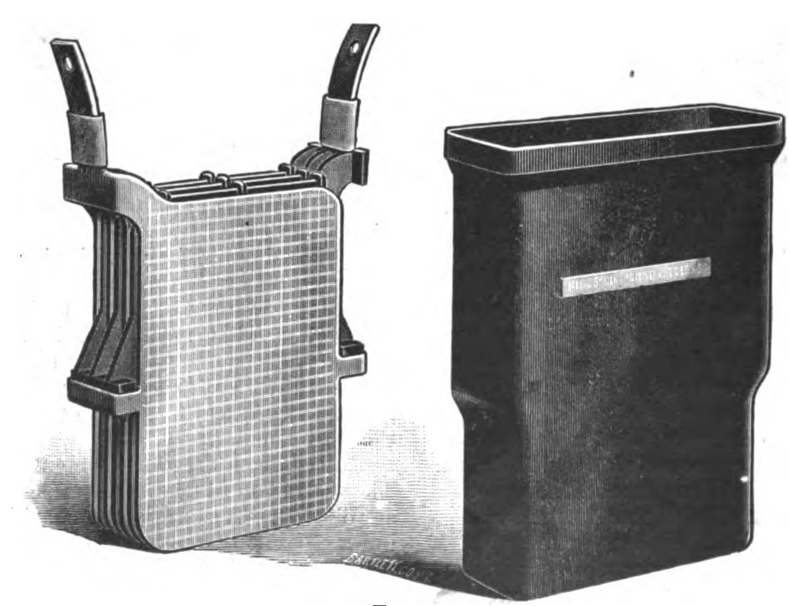


FIG. 20.

second solenoid magnet, P M, wound to high resistance. The armature lever of this second solenoid is so mounted that when its core is attracted or released this lever moves over a series of contact strips which are insulated from each other. Connected with these contact strips are coils of wire of suitable resistance, the whole constituting a simple rheostat, more or less of the wire of which is included in a local circuit, according to the position of the lever which acts as a movable contact. The solenoid magnet of the regulator A B and one or two cells of accumulators are also included in the local circuit referred to, the strength of the current flowing in this circuit depending upon the amount of resistance inserted by the movement of the lever of the pressure magnet P M. The latter magnet is connected directly with the battery terminals, and as the potential of the battery rises and falls the current flowing through this magnet varies correspondingly, causing a similar variation in the current in the local circuit. Thus an increase of pressure at the lamps, which are connected to the battery terminals, indirectly causes the armature of the regulating magnet A B to be attracted, and this in turn opposes one or more counter electromotive force cells in the lamp circuit until the pressure again becomes normal. If the pressure at the lamps falls below normal the regulator acts in the reverse way, cutting out the counter electromotive force cells until the normal pressure is again restored. If in connection with this method the polarized consumer's switch, previously mentioned, is substituted at s, the operation of such a substation will be entirely automatic.

It is proper to mention that the pressure magnet must be very sensitive and requires a delicate adjustment, besides being somewhat costly on account of the excellence of the workmanship required. Although I have only seen the instrument used in an experimental way, its practical application to similar purposes has given satisfactory results.

Under certain circumstances, as, for example, when a lighting station is worked to its full capacity at night but during the day time has ample surplus power, the all-accumulator system may often be applied to increase the capacity of such a station with satisfactory results. In

such cases the sub-stations of accumulators are located at distant points in the usual way, the cells being charged during the day and discharged on the lamp circuits at night while the power plant is doing its regular work. The arrangement of the accumulators and regulating apparatus in the sub-stations of the all-accumulator system is practically the same as when the half direct system is employed, except that a simple transfer switch which transfers the battery from the lamp circuit to the charging circuit, and *vice versa*, is used instead of the consumer's switch.

It is needless to say that all of the methods which have been described of employing accumulators in long-distance lighting may be adapted to existing lighting plants, and that when so adapted the earning capacity of such stations may be considerably increased without extending the capacity of the power plant. For this purpose there will usually be required a special dynamo at the central station, a charging circuit taking in the territory outside of the regular lighting limits, and one or more sub-stations with accumulators.

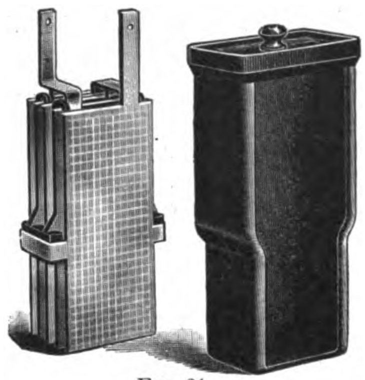


FIG. 21.

There are, of course, numerous other ways of utilizing accumulators in central station supply systems, such, for example, as the double battery method now operated in England by the Electrical Power Storage Co., in which the dynamos are kept running for 24 hours daily, duplicate sets of accumulators being alternately inserted in the charging and supply circuits at uniform intervals of time, by an automatic mechanical device. But I have limited this paper to a description of some of the simpler methods of accumulator regulation which may be readily adapted to ordinary lighting plants, and, in concluding, can only hope that I have succeeded to some extent, at least, in showing that when so applied in an intelligent manner accumulators do occupy a useful place in the industry of electric lighting.

Through the courtesy of the Electrical Accumulator Co., I am enabled to present to the Institute this evening the first proofs of some cuts of a new line of standard accumulators recently brought out by that company. The cells referred to are shown in figures 16 to 21 inclusive, and their dimensions and capacities are described in the following table :—

CONTRIBUTIONS TO THE CHEMISTRY OF STORAGE BATTERIES.[1]

BY E. FRANKLAND, D. C. L., F. R. S.

UNDER this title I communicated to the Royal Society, in February, 1883,[2] the results of some experiments on the reactions occurring during the charging and discharging of a storage cell. I showed that no appreciable part of the storage effect was due to occluded gases, as had been previously suggested by some chemists and physicists ; but that the act of charging consisted essentially in the decomposition of lead sulphate, whilst the discharge was produced by the recomposition of this salt.

The establishment of these, as practically the only reactions going on in a storage cell, enabled me to prescribe a very simple method by which the charge in any cell could be ascertained, for as sulphuric acid is liberated during the charging and absorbed by the active material of the plates during discharge, the amount of charge could at any time be measured by ascertaining the amount of free sulphuric acid in the cell ; in other words, by simply determining the specific gravity of the electrolyte ; and this method has since been very generally adopted by the users of storage batteries.

In continuing these experiments it soon became evident that the lead sulphate formed and decomposed in the cell could not be the ordinary white sulphate hitherto known to chemists, because, in the first place, the active material of the plates always remains colored, even after discharge ; and, secondly, because whenever white sulphate is produced through abnormal reactions in the cell, it is afterwards decomposed only with extreme difficulty by the electric current.

In order to obtain some light upon the composition of the sulphate formed and decomposed in the cell, I have studied the action of dilute sulphuric acid upon litharge and minium.

ACTION OF DILUTE SULPHURIC ACID ON LITHARGE.

Finely powdered litharge was treated with successive portions of dilute sulphuric acid until the liquid remains strongly acid after prolonged trituration. The resulting insoluble buff-colored powder was washed with water till free from acid, and dried first at 100° C., and afterwards at 150—160°. The loss at this higher temperature was less than 0.2 per cent., and was therefore due to hygroscopic moisture.

PbO and SO_3 were then determined in the dried compound as follows :—The salt was dissolved in a small

1. A paper read before the Royal Society, June 20, 1889.
2. Proceedings of the Royal Society, vol. xxxv., page 67.

LIST OF ELECTRICAL ACCUMULATOR CO.'S STANDARD CELLS.

(Approximate data.)

Figure.	Type of cells.	Charging current. Normal. Amperes.	Working rate and capacity. Amperes. Normal. Rate.	Normal. Ampere hours.	Maximum. Rate.	Maximum. Ampere hours.	External dimensions of jars. Inches. Glass. Length.	Glass. Width.	Glass. Height.	Rubber. Length.	Rubber. Width.	Rubber. Height.	Weight of acid. Lbs. Glass.	Rubber.	Weight complete cell. Lbs. Glass.	Rubber.	Height over all including connections. In.
16	15 L	15 to 30	30	300	40	250	10¾	12¼	13¾	—	—	—	50	—	130	—	15⅛
17 & 18	23 M	10 to 25	25	150	30	110	10⅜	8⅛	9⅞	6¾	7⅛	9 7/16	16	11	50	40	11⅛
19	15 M	5 to 15	15	100	20	70	7¾	8⅛	9⅞	4⅝	7⅛	9 7/16	11	7	35	25	11⅛
20	7 M	2 to 6	6	40	8	25	4¾	8⅛	9⅞	2⅝	7⅛	9 7/16	6	3⅛	20	18	11⅛
21	5 S	1 to 2	2	8	3	6	—	—	—	1⅞	3⅝	6 9/16	—	[illegible]	—	2⅞	7

Electromotive force of each cell is about 2 volts.

quantity of pure concentrated solution of caustic potash, and the solution, after dilution, was saturated with CO_2. (According to H. Rose, COPbo″ is soluble in $COKo_2$, but not in COHoKo.) Any excess of CO_2, which might have caused the COPbo″ to dissolve, was avoided by warming the liquid with the precipitate on the water bath to a temperature at which the COHoKo begins to dissociate. The liquid was then allowed to cool and stand 12 hours before filtering. The COPbo″ was filtered off, converted into nitrate, and precipitated and weighed as sulphate. The sulphuric acid was determined in the filtrate from the COPbo″.

1.2964 grms. of the salt gave 0.6647 grm. baric sulphate and 1.4437 grms. plumbic sulphate.

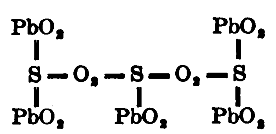
These numbers agree closely with the formula—

$$(^{3}{}_{2}(SO\ (PbO)_{5},$$

as is seen from the following comparison of calculated and experimental numbers :—

	Calculated.		Found.
$3\,SO_2$	240	17.71	17.61
$5\,PbO$	1115	82.29	81.96
	1355	100.00	99.57

These analytical results suggest the following graphic formula :—



The formation of this salt may be represented by the following equation :—

$$5\,PbO + 3\,SO_4H_2 - S_3Pb_5O_{14} + 3\,OH_2.$$

Litharge. Sulphuric acid. Buff lead salt. Water.

(*To be continued.*)

POINTERS.

.... EXCESS of pressure in a constant potential system means, as an electric light man once tersely remarked to me, "coal wasted, filaments busted, patrons disgusted."—*C. C. Haskins.*

.... THERE is always a triangular duel between the patron, the company and the coal pile on the subject of amperes, volts, candles, lamps and dollars.—*C. C. Haskins.*

.... THE great development in electricity will be, I am firmly convinced, in discovering a more economical process of producing it. At present we only get from coal consumed about four or five per cent. of its latent electricity. The rest is wasted in heating water, expanding steam, pushing pistons, turning wheels, and finally causing a dynamo-machine to operate. A process will ultimately be found for extracting 90 to 95 per cent. of the latent electricity directly from the coal. Then steam engines will be abolished, and that day is not far off now. Already we can get electricity direct from coal to the amount of 90 per cent. but only for experimental purposes. When I was on shipboard coming over I used to sit on deck by the hour and watch the waves. It made me positively savage to think of all that power going to waste. But we'll chain it up one of these days, along with Niagara Falls and the winds. That will be the electric millennium. —*T. A. Edison.*

ELECTRICAL NOTES OF A TRANSATLANTIC TRIP.[1]

BY THOMAS D. LOCKWOOD.

ALTHOUGH the English *Electrical Review* has heretofore been so good as to intimate in speaking of some of my pen productions, that they are characterized by such a mixture of practical information and humor as only a true born American could produce, yet it is a fact, as some among you have long been aware, that I am of English parentage and birth, and lived in England for the first 16 years of my life.

It thus came about that I was more easily enabled to assimilate in habit and thought with the English electricians whom I had the good fortune to meet, than is usual, and my visit, so far as the British Isles were concerned—though the first one in 24 years—was much like the return of a wanderer to his home.

The most difficult part of this paper was the choice of a suitable designation therefor. I cogitated over many, among others I thought for a moment of denominating it "A visit to Europa and the Bull ;" the Bull, of course, being playfully indicative of the domain of John of that ilk.

Calm contemplation, however, showed me that "Europa and the Bull" were out of question, and that such a title would have appeared in the highest degree anomalous to those who consider the United Kingdom as constituting a part of Europe. Moreover, it might be thought by others that, as I spent so little time on the Continent of Europe and saw so little of it, I was not authorized to speak so grandiloquently of my humble few days in France and Belgium ; and, inasmuch as many of my observations, for example, those on outdoor electrical construction, are equally applicable to continental and insular Europe, there might be some doubt in the minds of my auditors whether there was any clean cut line of differentiation between the two elements of such a combination title.

Indeed, while myself considering this composite caption, I was forcibly reminded of a remarkable passage in the life of the late Alfred Smee, Esq. (he who was principally known as the inventor of the Smee battery, in which polarization was prevented or materially retarded by making the negative plate of silver, coated with finely divided platinum), but who was really one of the most able of the early electricians and electro-metallurgists, and a general philosopher of high merit.

Mr. Smee, during the years 1845 to 1847, took a great interest in the potato disease, and his view that the disease was produced by the ravages of a variety of aphides excited considerable rancorous animosity and ridicule.

In a pantomine exhibited at Drury Lane appeared the following :—

Scene—A village with shows, etc.

Little Boy (looking at a peep show).

Showman, loquitor :—

"This is the Aphis vastator, as you may see,
Very much magnified by Mr. Smee."

Boy—"Please, sir, which is the aphis and which is the tater ?"

Showman—"Whichever you like, my young investigator."

And in the same manner had I chosen the enterprising title already referred to, my hearers might have felt disposed to enquire :—"Which is Europa and which is the Bull !"

My excursion from the time I left home until the day of my return extended over a period of twelve weeks, minus two days. I sailed from Montreal in the steamship *Vancouver* of the Dominion Line, and had a short passage, and over 48 hours of river and gulf sailing.

Passengers taking this route have a very short sea space and a correspondingly long and delightful smooth water and land-locked experience ; they have a greater chance of seeing icebergs, whales and porpoises ; with a certainty of cooler weather and a reasonable possibility of rougher seas. I returned in the *City of Rome*, the only Anchor Line steamer plying between Liverpool and New York.

I stayed on my arrival in England a few days in Liverpool, passed on to the Derbyshire peak district, then to Birmingham. From thence I went to London, making my head-quarters not in the city, but in a most beautiful town, Tunbridge Wells, which is an inland watering place some 30 miles distant, in Kent. Later I passed over by way of Dieppe to Paris, and, after a few days there, returned to England through Brussels and Antwerp.

After staying a few days more in London, I went to Scotland, calling at the cathedral cities of Lincoln and

1. Read before the American Institute of Electrical Engineers, New York, October 15th, 1889.

York, and at the manufacturing city of Newcastle-on-Tyne. I halted at Edinburgh, passing on later to Inverness, via Perth; and then down the Caledonian canal to Glasgow and back to London, stopping en route once more at Edinburgh. Then I took a side trip from London to Salisbury, Bath, Gloucester and Worcester, and again returned to London via Oxford. Finally I started from London to Chester, a most charmingly antiquated walled city, visited some of the North Wales watering places, inspected the mediæval castles of Conway and Carnarvon, climbed Snowden; sailed from Holyhead to Dublin; took railway to Cork, passing the celebrated Blarney castle and stone; spent a day at Killarney, and took ship at Queenstown.

My visit was not a business trip, and I made no attempt to combine pleasure with business, but it is hardly necessary to say that I did not travel with my eyes shut; and that when anything electrical came before me, I had no hesitation in making observations on it. However, my observations were somewhat desultory, and my account of them will necessarily also partake of that character.

TELEGRAPHY.

I saw little of interest in telegraphy until my arrival in London, where I lost no time in looking up Mr. William H. Preece, the well-known electrician of the British telegraphs, whose urbanity and good nature were as usual far above par. By his favor I was able to inspect the central telegraph station, which is located in an immense building in St. Martins Le Grand, just opposite the general post-office building proper.

I was placed in the care of Mr. Cooper, a genial gentleman, charged to a high potential with useful information, and in his company paid my respects to Mr. H. C. Fischer, the controller of the central station.

Mr. Fischer, with whom I had had some previous acquaintance during his visit to America in 1877, made strenuous efforts to recollect me, and I think succeeded, although I am not sure. But if his recollection was not perfect, it was at least a good imitation, and did not in the least interfere with the cordial reception which I received at his hands.

The London operating room, or rooms, is an immense affair. Heretofore I had a most exalted opinion of the size of the Western Union room in New York, but the London room was a decided revelation. I noticed a very peculiar effect there. When first introduced a good sized room filled with operators, or more properly telegraphists, and apparatus dawned upon my vision; and together with Mr. Cooper and the superintendent in charge I wandered through it; but near the end we suddenly turn a corner, and another vista, as wide and long as the first, appears, which again we traverse only to find once more, as we approach its farthest limit, that a third vast expanse lies before us, and so on apparently for half a dozen successive times. Then I was led upstairs, where a similar succession of rooms was exhibited to my bewildered gaze.

Morse instruments, both sounder and ink writer, were there to be found. The single needle also appeared to hold its own, and I saw something new to me, viz.: telegraphists reading by sound from the click of the single needle as it vibrated from one side to the other, striking its limiting stop.

With respect to the Morse, I do not think the average transmission is as fast as is the American average, nor do I think it possible to achieve extremely rapid sending with the heavy keys generally in use.

I was greatly interested with the way in which the Delany multiplex has been taken up by the British telegraphic authorities. It may have been in some degree improved and modified, and I understood that the number of circuits, simultaneously worked successfully, were not as great as had been hoped for, but still it was in use; its use was increasing, it was doing good work on lines of considerable length, and the operators liked it.

Upon making inquiries about the Wheatstone automatic, it was to be noted that while authorities united in enthusiastic praise of its qualifications as a fast telegraph in all cases where the matter transmitted was to be received in duplicate or in multiple, such as news; the praise was by no means so emphatic with respect to its ordinary use as a means of transmission for business messages, as so much time was required to be taken up in the preliminary measure of punching.

The pneumatic despatch branch of the London station is on an equal scale of immensity, and, in fact, is one of the great features of London telegraphy. Throughout the length and breadth of the land I found civility and prompt attention in the matter of receiving and delivering telegrams. Early and late I tested the telegraphic service and found it up to the mark.

It is, I believe, a regulation that all telegrams are to be prepaid by stamps; the said stamps in all cases to be affixed by the sender. The former of these provisions is no doubt invariably carried out, but, as the latter is not always, I cannot speak positively as to either.

As a matter of fact, I was rarely required to affix my own stamps in telegraph offices in large cities, whereas the letter of the law was fully carried out in small places; the principle being, I suppose at these places, to make up in formality for what was lacking in amount of business.

The facilities for telegraphy in the United Kingdom are wonderfully complete, and I found no place too small for a telegraph office; moreover, in my opinion, telegraphy is there cheap, in spite of the fact that the address and signature has to be counted in and paid for.

The dynamo does not appear to be employed as a source of telegraphic currents, and here, I think, the British telegraph system is a little behind the times. Yet, as far back as 1873, I understand that Mr. Preece experimented with the Gramme machine for this purpose, but found it too unsteady for the Wheatstone automatic instruments.

There are 23,000 cells of battery in use at the central station in London, and 220 circuits are supplied by accumulators.

Do I approve of the telegraphs being owned by the government? In a monarchy, whether limited or absolute, yes. Because the government is permanent and usually stable. It answers well in England, it is cheap and good. But does it pay? Well, if you consider that the agencies of a government should be administered for the people's benefit, I think it does. But for a republic, at least one like ours, in which radical and sweeping changes of administration occur at frequent intervals, I am clearly of the impression that a government ownership would be an unqualified evil. No doubt a government control leads to a superabundance of red tape; to the ridiculously excessive formalities of the circumlocution of office, and to extreme conservatism. It also acts as a damp sheet upon invention. Yet, in spite of these tendencies, the telegraphs of the British Isles are, I think, on the whole better managed and better manned than they would be by one or more corporations; and the question of remunerativeness seems to me quite of a secondary character, since, even though the telegraph department be not profitable, it seems at least evident that the people are enjoying a lower rate than they would under other circumstances be entitled to or receive.

The rigid rule of discipline was, however, well illustrated in an attempt which I made to see the telegraph office at Birmingham, but where I was told that they would have to write to London for permission to allow my visit. I could not wait the exchange of correspondence, and thus have not, as yet, seen the telegraph office there. It seems the telegraph department does not use its wires at all on office business, but employs the mail altogether, the wires being reserved exclusively for paid business.

ELECTRIC LIGHTING.

From my point of sight as an electrical engineer I was disappointed to find that electric street lighting was, com-

paratively speaking, still a thing of the future nearly all over the kingdom. Not that electric lighting is not being done, but that so little of what can be done is seen. Instead of having electric illumination all around you, as we have it, we have, so to speak, to hunt up installations.

There are a number of central station plants in London, but London is an immensity, and might contain many more, and yet electric lighting would be conspicuous by its paucity. You may, for example, walk through Holborn and Oxford street and see lines of glorious shops lighted electrically; you may go to Grosvenor Gallery and watch the historical illumination there, and you may at various factories see that the electric light is for this class of work being extensively employed.

The Great Western Railway Station at Paddington is lighted up by 100 arc lamps and an infinity of incandescent hairpins; and many seaside resorts know of the electric light; while at Glasgow and Liverpool are central lighting stations of high capacity; but, in spite of all this, you cannot help forming and bringing home the impression that there has been but little done in comparison with the immense amount which remains undone in this branch of electrical application. The truth is, that the British public seems to have had a surfeit of electric lighting companies at an early date, with all that an electric lighting company implied, in the years 1878 to 1882, and has of late years had no wish to take a second dose.

As a telephone electrician, I felt disposed to congratulate the telephone and telegraph people that they had escaped the horrors of burned out central stations and disturbed circuits.

Such lighting companies as may hereafter undertake to occupy this field are also to be congratulated that they will have the several years experience of others and all of the many improvements which have been produced in apparatus and insulation to profit by. I think that municipalities in England will themselves shortly take up this matter. In no case, I am sure, will " undertakers' wire " or the reckless class of construction, which we have too often seen in this land of liberty, be tolerated.

Isolated house lighting is, however, well advanced. Enquiries which I made proved that this branch of incandescent electric lighting, which has overflowed upon the steamships and boats, is very popular. In the several examples of it which came under my personal notice the electricity is drawn from secondary batteries, which are during the day charged by a dynamo.

I had the happiness of dining with Mr. W. H. Preece at his house at Wimbledon, and of examining his lighting plant. He uses the secondary cells of the Electrical Power Storage Co. The plates are formed of a leaden grid, the perforations of the positive plate being filled originally with minium, while those of the negative plate are filled with litharge. The charging dynamo was run by a gas engine, and Mr. Preece informed me that it cost him exactly as much for gas as it did when he used gas for illuminating purposes, while he had a much greater amount of light. I am bound to state that, in my opinion, the light was superb, being apparently softer and more equable than when operated directly from the dynamo.

While upon this subject I may state that I also had the pleasure of inspecting the beautiful laboratory and workshop of Sir David Salomons at Broomhill, Tunbridge Wells. Sir David is a wealthy amateur who has made the realm of secondary batteries peculiarly his own, and who has written a text book on their construction and care, which, if not absolutely faultless, is certainly the most useful and practical work on the subject in existence. He has a pair of fine compound steam engines and several dynamos, these being connected with the prime motors by leather link belts of American manufacture.

A great number of storage cells, several hundred I should judge, and in prime condition, are located in a side room floored with glazed tile, the entire floor sloping to one side for the purposes of drainage. In the machine shop I saw some of the finest machine tools that my eyes have ever fallen upon—lathes, drills, planers, sharpers, and so forth—and it was particularly noticeable that each machine was provided with its own electromotor. All of the motors were of the Elwell Parker make. Upon a shelf in the laboratory office were a few well chosen books, among which I noticed the last bound volume of the proceedings of this Institute.

Sir David uses these motors for every conceivable purpose, furnishing electric light and power for his entire establishment; and while I was there electricity was employed in making butter. If an electrician whose heart is in his work is ever justified in cherishing envy in his bosom, it is when visiting such a place as that of Sir David Salomons, and he has my heartiest acknowledgements for the kind way in which he allowed me to inspect the same, though himself absent.

I saw throughout my travels little in the motor line, except those to which I have referred, but I am informed that the use of electromotors in Britain is already great and is rapidly increasing.

TELEPHONY.

The chief centres of good work in telephony are Dundee, Glasgow, Liverpool, London, Edinburgh, Manchester and Birmingham. The fact that I mention Birmingham last shows that no attempt at classification has been made. I could not inspect the Liverpool central station, as I happened to be there only during holidays, when the authorities were all absent; and, for lack of time, I was unable to visit Manchester at all; but I saw a good deal of the Liverpool outside construction, and I heard enough about Manchester to assure myself that the installation was par excellence.

Many of you will be aware that three of the principal telephone companies in England, viz.: the United, the National and the Lancashire and Cheshire have recently joined their forces under the name of the National Telephone Co., Limited.

This company has now taken charge of the London exchange, where I was rather surprised to find that there were already more than 7,000 subscribers.

There nearly all lines were built over the housetops, with tubular iron fixtures of a construction, beautiful and light and yet strong. A very peculiar feature of this London construction was that the wires of a route were, as a rule, all strung in a vertical plane, there being very few cross arms. This made a very symmetrical appearance, but it struck me that it was hardly a sufficient utilization of a route, or, as the Britons say, of the " way leave." This, however, was the work of the United company, and I think was not in accordance with the judgment of the engineer of that company, who remains in the same capacity with its successor.

The post-office department charges the telephone companies a regular royalty, it having been legally decided that the telephone is a " telegraph " within the meaning of the statute. The Postmaster General apparently does not like the actions of the companies in uniting, although none of them were competitive, but all working in distinct territories. There is no doubt, however, that he fears that the capitalization will unnecessarily enlarge, and will be a big bite for the government mouth whenever, and if ever, purchase may be decided upon.

It does not seem to me likely that the Postmaster General will take any steps to harass the companies, nor do I believe that the post-office telegraph department will care for a long time to come to trouble itself with telephony; and it is my opinion that the remaining telephone companies will soon in turn be absorbed or otherwise unite with the National company.

Long-line telephone work in Great Britain is, of course, limited by the size of the island, and by the peculiar rela-

tive position of the large towns. I found very good talking between Birmingham and the several towns of Sheffield, Derby and Nottingham; between Glasgow and Edinburgh and Dundee; and especially fine from Sunderland to points upward of a hundred miles distant. For these latter distances, circuits had to be artificially made up. In London there are necessarily many central telephone stations. No one who has not seen and studied London, can form an idea of its vastness; and by reason of this vastness there will always be (notwithstanding the manifest excellencies of centralization) a plurality of central stations connected by trunk lines, mainly converging to a principal trunk station; but supplemented by a sufficient number of trunks between such central stations as are adjacent to each other. Yet I should say that there are at present too many central stations, and that they are too close together; and I am under the impression that the present management thinks so too, and will condense closely grouped central offices considerably

In Scotland I found a regular multiple switch-board in the Glasgow central station, which was the most American looking central station which I have seen anywhere. In Glasgow, also, a "nickel in the slot" toll box has been devised, and is largely used at public stations, a penny or a certain number of pennies being the local charge, and a sixpence or more, the trunk line, or out of town charge. The operator can tell by peculiar sound signals automatically given by the passage of a coin or coins, whether the proper amount is dropped in; and, if not, the machine simply absorbs what has been put in and does not grant the desired accommodation. Regular subscribers have a check-key which operates the apparatus without requiring the electro-deposition of a coin. This machine is well spoken of, and is said to give satisfaction. In some other parts of England, these boxes are also used, and non-subscribers to the exchange may purchase a local check-key for the purpose of using at any time the public station without having to pay every time. It may be of interest to state that at every railway station in England the "nickel in the slot" or rather the "copper in the slot" machine applied to a variety of uses, is to be found. The weighing machine is the most popular, but the electrical shocking machine is a close second.

The best working long lines which I found were without doubt those belonging to the Northern District Telephone Co. This company is in charge of Mr. C. B. Clay, of Sunderland; the lines are new and are built of the latest model.

In Newcastle, all lines, both telegraph and telephone, which are owned by the government are underground. They work very well and the government telephone system there is ably managed by Mr. A. W. Heaviside, who based his telephone exchange upon a pre-telephone exchange, actually in existence in Newcastle and operating dial telegraphs, long before the telephone exchange was thought of, or the telephone itself invented.

The National Telephone Co. is fortunate in having such men as Messrs. Bennett, Coleman, Jackson, Phillips, Sinclair, and as far as possible, employs men trained by previous education and experience to be equally efficient in a business and technical capacity.

As to electrical construction outside, I may say without hesitation, that the average is far above ours, whether telegraphic, telephonic or otherwise. The poles are no longer than are necessary, are uniformly well trimmed and painted, and above all, are well stayed. Mile after mile I have ridden on a railway both in England and on the Continent, and found *every* pole "stayed," or, as we would say, "guyed." The cross-arms are usually short, and project alternately a greater distance to one side or the other, that is, the upper cross-arm may carry two insulators on the right side of the pole and but one on the left. While the next will reverse that, two being on the left and one on the right, and so on. The telephone companies had much house-top construction, but the same system of staying prevailed, so that the construction was superb, even though the roofs were all of the pitched variety. In Sunderland only, and the other towns where the Northern District Telephone Co. holds sway, are to be found long cross-arms *à la American*, the idea having been imported by Mr. Clay who visited the United States a year or two ago, and who is a manager of the most progressive type.

In Edinburgh, though nearly all wires were overhead, they were so symmetrically arranged as to be hardly noticed. Mr. A. R. Bennett, who is general manager of the Edinburgh district, looks also after Dundee, Galashiels, Dumfries, and many other towns.

The above remarks apply alike to the government construction in Great Britain, France and Belgium, and to the construction of telephone companies.

The only underground telephone line work which I found was the well-known Paris sewer work, and the government telephone exchange wires at Newcastle upon Tyne; but the National Telephone Co. is beginning to lay some underground wires in Birmingham.

At Birmingham also, I noticed some little pole work, and it was both amusing and instructive, to see that, wherever possible, the poles were modestly planted close to the gable end of a block of buildings; or inside of a high fence; or in the corner of a vacant lot, so as to attract as little notice as possible.

I found that silicious bronze wire was well thought of throughout the several territories which I visited, and in general use. It can be made of a conductivity nearly as high as copper, while it is tougher; and it is much better for telephone work than iron, because not only is the conductivity higher, but it possesses a much lower co-efficient of self-induction.

One telephone span I saw in the south of England crossing the opening of the Dartmouth harbor, which was certainly not much less than half a mile in length. I venture the prophecy that in the near future we shall use silicious bronze here in the United States much more than heretofore we have done.

In France I visited, of course, the Exposition, and met Messrs. Abdank-Abakanowicz and Berthon, both old friends. The finest electrical affair about the exposition to my mind, was the way in which the great fountain was illuminated in kaleidoscopic colors every night. This has of course often been done before, but never, I think, so perfectly or on such a scale. The success of the installation is due to Mr. Aylmer, who has had it in charge.

I stood in the tower and admired, and then I went down through the tunnels and stood beneath the fountain, where the arc lights were reflected through colored screens, and through the plate glass floor; and marveled and admired still more; especially when I saw how the levers arranged in the tower like those of the Pennsylvania railway signal tower worked pneumatically the screen mechanism below, and kept an ever changing succession of beautiful colors upon the different fountain jets; and all this apparently, so far as the crowd could see, working itself; for there was no manifest link between the operating tower and the fountain.

The exposition telephone station as arranged by Mr. L. Berthon was a sight in itself, with its multiple switchboard; its closets for private communication; its samples of fine electrical apparatus made by the Sociètè Generale des Telephones, and its apparatus and circuit arrangements for receiving operatic performances, and reissuing them for the delectation of numerous auditors.

Long telephone lines stretch from Paris to Havre, Lille, Bruxelles, Lyons and Marseilles, and work admirably. These are chiefly of copper and are arranged in metallic circuits.

Mr. Berthon, the managing engineer of the Sociètè Generale des Telephones, told me that his company while sparing no effort to keep up its efficiency, had for some little time been lying on its oars in view of the possible

purchase of its telephonic property by the government. And as you are aware, the government has since decided to acquire this property, and has in fact taken possession of it, which action, I believe, to be an unfortunate one, alike for the government, the Sociètè and the people.

Of course the great Edison exhibit with its 9,000 feet of floor space was a tremendous affair, and although it would naturally impress the observer without any extraneous aid, it is fair to say that its merits were literally hammered into the visitor's mind by the able enthusiast who had it in charge.

This, together with the surpassingly fine exhibit made by the Thomson-Houston company in association with the Thomson Electric Welding Co., and also the unique historical exhibit, made by the American Bell Telephone Co., fully redeemed the electrical section, from any participancy in the otherwise too true charge that the share of America in the great exposition was comparatively insignificant.

The compound engines, built by Messrs. Davey, Paxman & Co., of Colchester, England, to run the dynamo for lighting the fountain tower, and exhibition, were an interesting sight to me. I was delighted to watch their fine and speedy regulation as the requirements varied. The young man who was running them, was a rising electrician, Mr. H. D. Wilkinson, the same who succeeded Mr. Kennelly in the authorship of the series of electrical measurements articles lately published by the London *Electrician.*

Mr. Wilkinson, believing it right to give himself a practical intimacy with all branches of electrical engineering, was taking this method of doing so, and illustrating the English tendency to carry out to the fullest extent the scriptural maxim "whatsoever thy hand findeth to do, do it with thy might."

I was favored by Messrs. Siemens Bros. and Co., by permission to visit their works at Charlton, Woolwich. There I found active work going on in all branches of electrical manufacture, but the most new and interesting feature to me was the submarine cable work which I witnessed in various stages. This I could not avoid reflecting, is the one branch of electrical work in which Britain is practically without competition. Here I met Mr. Frank Jacob, the electrician of the Siemens's company; a remarkably able and intelligent man, and the inventor of one of the earliest systems of multiple telephony and combined telephony and telegraphy. A most interesting feature of the Siemens's works is the testing room, where every foot of cable is tested during the process of manufacture. Immediately across the river, and thus an opposition physically as well as commercially, is the rival cable establishment of Silvertown.

Speaking of manufactories, brings to mind that the tendency of the British business public to consolidations (or amalgamation as it is mercurially termed) after having swept over all the breweries, distilleries, and gas companies within reach, and after having touched the telephone companies, is now exerting itself upon the electrical manufacturing interests; as evidenced by the fact that all of the storage battery companies and electric railway companies have amalgamated to form "The Electric Construction Corporation, Limited," and that the various Woodhouse and Rawson manufacturing companies have also consolidated into a large joint stock corporation.

While in Birmingham, and engaged in visiting the local lions, I went to see Aston Hall, the free museum of the town.

In one of the many interesting rooms there, I observed on exhibition, an old fashioned large magneto machine designed, as an inscription thereon informed me, for use in electro-plating. Upon close inspection, I found it to be the first magneto machine ever designed for that purpose; namely, that made and patented in 1842 by Stephen J. Woolrich. This machine was presented to the museum, by Thomas Prime and Son, electro-metallurgists, of Birmingham.

Passing through the cathedrals and abbeys of Great Britain, my bosom, like that of Sir Joseph Porter, K. C. B., swelled with pride, to note how these buildings and their precincts were made into a species of mundane Valhalla, where the worthies of the nation, distinguished in war, science, or literature were immortalized, and their memories treasured, for the example and encouragement of their countrymen, and as a mark of appreciative acknowledgement of their services rendered to their country.

In Westminster Abbey I remarked the tombstone of William Spottiswoode, electrician and philosopher, while in the abbey and churchyard of Melrose I noticed respectively the graves of Michael Scott, and Sir David Brewster, one the friend of True Thomas, the Rhymer, of Ercildown and the scientist par excellence of the 14th century; the other one of the more fortunate wizards of the 19th century; Michael in his day was called a "wizard," but would probably now be called an electrician.

In conclusion, I desire to say that the cordial and fraternal manner in which everywhere I was received by electricians, and by those interested in electrical development, and the hearty hospitality which I received, merit and receive on my part the profoundest appreciation and the warmest reciprocal feelings of kindliness.

Never from the moment that I set my foot on European shores until the moment of departure had I any need to feel that I was a stranger in a strange land.

THE LAW OF "INVERSE SQUARE."

BY TOWNSEND WOLCOTT.

THROUGHOUT the whole domain of physical science there is perhaps no quantitative law which has occasioned more misunderstanding than the so-called law of inverse square.

The non-mathematical student of science nearly always misapplies the law, obtaining in some instances results as far from the truth as though the law had no existence, and even mathematicians have sometimes held that the law is only approximate.

In the present state of science, however, there is no physical fact which rests on stronger evidence than the law of central forces, which in a particular case becomes the law of inverse square. That is, the force is inversely proportional to the square of the distance; exactly, not approximately.

We will first illustrate the meaning of this law and then demonstrate its truth.

Even before Newton it had been conjectured that the heavenly bodies might attract each other with a force inversely proportional to the square of the distance between them. Newton was the first to give an experimental proof in the case of the moon, an achievement which has lost none of its lustre in the two centuries since elapsed.

Now what are we to understand by the distance between two bodies? Is it to be measured between the nearest points, or the centres of figure, or centres of gravity? In the case of the heavenly bodies, their diameters are so small in comparison with the distance between them, that except in the most refined investigations, it makes no sensible difference which of the distances we take.

In some other cases we may assume the mass of each body to be concentrated at one point and then take the distance between these points. For instance, in a homogeneous sphere, and in a sphere consisting of concentric layers, each layer being of the same density throughout itself, but of a different density from the other layers, we may take the centre of figure. But the solution of particular cases is not our principal object. The only perfectly general method of treating the attraction between two bodies, is to take the sum of the attractions between each element of volume of one body, and each element of the other body. This summation requires a sextuple integration, and in the general case cannot be performed.

The very fact, however, that the law of inverse square applies to the infinitely small elements of volume would insure that it could not be true for the whole masses after six integrations, except in special cases.

This is one point which is generally misunderstood by those who are not familiar with the calculus. The intensity of light radiating from a point, follows the law of inverse square, and the reason seems to be generally understood; namely, that the intensity is inversely as the area over which the light is distributed. This is the key to the whole subject. All known central forces (both attractions and repulsions), vary in intensity as the areas over which they are distributed. Electric currents also follow the same law if we substitute density of current for intensity of force. This, moreover, is only another way of stating the law which applies to currents of water or other incompressible fluid, the analytical statement of which is called the equation of continuity, and expresses the fact that the quantity of water which passes in a given time over each section of the current is the same.

Newton's calculation from experimental data in the case of the moon, and like experiments were for a long time the only evidence on which the law of inverse square rested. Now, however, the tables are turned, and the law is so well established as to be a test for the accuracy of experiments. The conservation of energy is now considered the crucial test for all physical theories, and the law of inverse square is a direct deduction from the conservation of energy.

So not only are we confident of the truth of this law in regard to all known central forces, but we are also confident of its truth in regard to any now unknown forces which may in future be discovered, if such forces there be. The mathematical investigation of the subject is as follows:—It is well known that the only law of force consistent with the conservation of energy is, that the force is a function of the distances only between any number of attracting points. If we resolve the force R at any point into its components parallel to the co-ordinate axes, x, y and z, according to the well-known method of the parallelogram of forces, and write for these component forces respectively, X, Y and Z, then $X\,d\,x + Y\,d\,y + Z\,d\,z$, is a complete differential of a function of the three independent variables x, y and z.

If $d\,s$ is an element of the arc of a curve, ε, the angle between the tangent and the resultant force R, then $\int R \cos \varepsilon \, d\,s$ is called the line integral of the force along the given curve.

It is demonstrated in Maxwell's Electricity, article 19, that where $X\,d\,x + Y\,d\,y + Z\,d\,z$ is a complete differential, the line integral of the force between two points, is the same for all paths between the points. That is the work done by or against the force, as the case may be, in moving an attracted particle from one point to the other, is the same for any path. Were it different for two paths we might move the particle against the force over the path of less work, and allow it to be moved by the force over the path of greater work, thereby giving an inexhaustible supply of energy by continuing the motion indefinitely. There is an apparent exception in the case of cyclic regions, that is, regions in the form of a ring or combination of rings or loops. In this case the line integrals for two paths which cannot be made to coincide by continuous motion without one at least of them passing out of the region, are in general different.

Here we do actually have an indefinite supply of energy, but the only cases of cyclic regions, which occur in practice are the fields of magnetic force which surround electric currents of various forms, and we know by experiment that the energy is subtracted from that of the currents, and doubtless if any other cases of cyclic regions should be discovered, there would be a similar explanation. Let S be any surface in the field of force, and ε be the angle between the normal to the surface drawn toward the positive side, and the direction of the resultant force R at the normal point, then $\int\int R \cos \varepsilon \, d\,S$ is called the surface integral of the force. It is demonstrated in Maxwell's Electricity, article 21, that if X, Y and Z are continuous and finite throughout the space occupied by the surface, $\int\int R \cos \varepsilon \, d\,S = \int\int\int \left(\frac{d\,X}{d\,x} + \frac{d\,Y}{d\,y} + \frac{d\,Z}{d\,z}\right) d\,x\,d\,y\,d\,z$. S being a closed surface.

If at every point $\frac{d\,X}{d\,x} + \frac{d\,Y}{d\,y} + \frac{d\,Z}{d\,z} = o$, then the surface integral over every closed surface in the space is o, which is simply the analytical statement of the fact that there are no centres of force within the surface.

For if there are no centres of force within the surface, any force which emerges from one portion of the surface, must have entered at some other portion of the surface, while for any centre of force within the surface, the force is all directed outward through the surface so that the surface integral for the whole surface cannot be zero.

Draw a tubular surface in such a way that its sides are formed by lines of force, then the equipotential surfaces will form normal sections of the tube. As there is no force acting through the sides of the tube, and as any two of the sections together with the included portion of the sides form a closed surface over which the surface integral is zero, the surface integral of the force directed inward at one end of the tube, equals that of the force directed outward at the other end. In other words, the surface integral of the force over every cross-section of the tube is the same. Now, if the lines of force are simply the radii of a sphere, the sectional areas of the tube are as the squares of the radii, and as the total quantity of the force acting through each section is the same, its intensity at any section is inversely as the area of the section; that is, inversely as the squares of the radii.

In case, however, the lines of force are of any other form, the distribution of the force is not uniform over the whole section except where the tube is infinitely small; in which case we may still say that the intensity of the force is inversely as the section of the tube. However, this mode of statement does not lead to any practical results; therefore the differential equation $\frac{d\,X}{dx} + \frac{d\,Y}{dy} + \frac{d\,Z}{d\,z} = o$, is to be preferred.

If V is the potential $X\,d\,x + Y\,d\,y + Z\,d\,z = -d\,V$, therefore, $= -\frac{d\,V}{dx}$, $Y = -\frac{d\,V}{dy}$, and $Z = -\frac{d\,V}{d\,z}$. We may therefore write the foregoing equation $\frac{d^2\,V}{d\,x^2} + \frac{d^2\,V}{d\,y^2} + \frac{d^2\,V}{d\,z^2} = o$, which is known as the equation of Laplace.

As before stated, this demonstration applies only to the free space about an attracting body where there are no centres of force, that is, no attracting particles. Within the mass of the body the law of attraction is different. Whatever be the distribution of force near the body, as the distance becomes greater, the distribution approximates to the spherical one, and at a distance which is infinite as compared with the dimensions of the body, coincides with it.

Therefore the law of inverse square is generally true, for the elements of volume of a body taken individually, and as we have already seen it is true for the whole body in special cases.

Let us now examine the logical value of the demonstration just given. According to Jevons, in his Principles of Science, deductive reasoning is certain, and its results are worthy of the same degree of credence as the premises.

The premises assumed are, first, the conservation of energy, second (if it be an independent assumption), the parallelogram of forces, which is at the very foundation of the science of statics, and the inference is drawn by the deductive processes of mathematics.

Maxwell gives a demonstration of the law of inverse square for electricity, as a consequence of the experimental fact that the charge on a conductor in equilibrium is entirely upon the surface.

The demonstration is very conclusive, as the experiment is susceptible of exceptional accuracy.

However, in the demonstration it is assumed that the force has a potential, from which it follows that in the space around the conductor the equation of Laplace holds true, and consequently the law of inverse square also even without the rest of the demonstration. We may therefore regard this experiment as an additional proof of the conservation of energy, or if we regard the conservation of energy as sufficiently well established, the superficial distribution of the charge on the conductor is a consequence of the conservation of energy, and the experiment is interesting as one in which we can test the theory to a very high degree of accuracy. Maxwell says, one part in one million.

ABSTRACTS AND EXTRACTS.

THE E. M. F. DUE TO THE ACTION OF LIGHT ON SELENIUM.

In a recent number of Wiedemann's *Annalen*, W. von Uljanin describes an interesting series of experiments on the E. M. F. produced by the action of light on selenium. Fritts, an American observer, had used gold leaf electrodes, but the gold leaf is very liable to peel off, and the author, therefore, discarded it in favor of platinized glass plates. Thin layers of platinum possess the additional advantage of allowing all the rays of the spectrum to pass with equal freedom. The selenium was melted in between the two plates, fixed parallel to each other, cooled under pressure, and then reduced from the amorphous to the sensitive crystalline form by being heated once or twice up to 195° in a paraffine bath, and then allowed to cool slowly.

The following experimental results were obtained :—

(1) The effect of exposing one of the electrodes to the action of light is to produce an E. M. F. from the dark to the illuminated electrode. The highest E. M. F. obtained was 0.12 volt, and it was always found to disappear completely and instantaneously when both electrodes were darkened. The difference in the behavior of different plates was very slight.

(2) Plates prepared by other methods were found to give very variable results, some giving an E. M. F. in the same direction when either electrode was illuminated, but the effect was in these cases always greater when the negative electrode was the one exposed to the light.

(3) If the electrodes are kept joined through a wire for many hours the current from the dark to the illuminated electrode continues to flow with undiminished strength.

(4) When both electrodes are illuminated together the current can be weakened to any desired extent or reduced to zero.

(5) The action of light is instantaneous.

(6) Many of the plates were found to be subject to polarization, but it had no effect on their sensitiveness to the production of E. M. F.

(7) When the E. M. F. of polarization has attained a sufficiently high value it is diminished by the exposure of either electrode to the action of light. For smaller values of the E. M. F. the effect of light is of the normal character described under (1). The limiting value below which the effects of light were normal was found to vary considerably for different specimens.

(8) The resistance, and the sensitiveness to the production of E. M. F. when exposed to light, in general diminish gradually with lapse of time.

(9) Both the resistance and the sensitiveness to the production of E. M. F. are much increased by passing alternate currents from a small coil through the plates, and those which have lost their sensitiveness through lapse of time can be restored to their original condition by continuing this treatment for a sufficient length of time.

(10) With weak sources of light, and when the heat rays are excluded as completely as possible, the strength of the current is found to be proportional to the intensity of illumination of the electrode; but with stronger sources of light, without exclusion of heat rays, the current strength increases more slowly than the intensity of illumination. The E. M. F. in this case seems to increase more slowly than the conductivity.

(11) In the diffraction spectrum the orange-yellow rays were found to produce the greatest effect, and the greenish-yellow rays in the prismatic spectrum.

The initial resistance of the specimens employed varied from 40,000 ohms to 900,000 ohms in the dark. The resistance of the specimen with the latter initial resistance gradually increased up to 1.4 megohm. The plates prepared by the author's method were found to be exceptionally sensitive to the action of light on their resistance, the effect of exposure to light being to diminish the resistance to about one-ninth of its initial value.

The author explains the results obtained on the hypothesis that the selenium in the plates exists in several allotropic forms, some only of which are sensitive to the action of light with respect to the production of E. M. F. He further supposes that some of the particles consist of combinations of different allotropic forms, or of selenides of the metals, of which traces existed in all the specimens experimented on. The effect of light he assumes to be to transform the sensitive particles into others electro-positive to them, and to facilitate the re-combination of the electrolytic molecules which have been taken up by the passage of the current.—*Electrician* (London), Sept. 13, 1889.

A NOVEL ELECTRIC BATTERY.

A NOVEL and simple form of electric battery has recently been invented in Italy. As described in the *Rivista Technica*, it consists of conical vessels of cast-iron and porous earthenware, with nitric and sulphuric acid. An iron cone is placed point downwards in a stand, and is partly filled with strong nitric acid. Into this there is placed a cone of porous earthenware containing dilute sulphuric acid. Then follows an iron cone surmounted by an earthenware one, and so on in a series, each vessel containing its respective acid. It follows that the inner surface of each iron vessel is bathed in nitric acid, and becomes passive, acting the part of the platinum or carbon in an ordinary cell. The outer surface is attacked by the dilute sulphuric acid, and takes the place of the zinc. There are no connections to make, the simple building of the pile putting all the parts into union. The earthenware cones are eight inches in diameter and four inches in height, and contain 550 cubic centimeters of 10 per cent. sulphuric acid solution. The iron vessel contains 110 cubic centimeters of nitric and sulphuric acids, the latter being three times the volume of the former. Sixty elements, arranged in two piles, have a resistance of $10\frac{1}{2}$ ohms, an electromotive force on open circuit of 81 volts, and on closed circuit of 45 volts, with a current of $4\frac{4}{10}$ amperes. After five hours the difference of potential falls to 28 volts and the current to $2\frac{7}{10}$ amperes.—*Science.*

LOMOND'S PITH BALL TELEGRAPH IN 1787.

The following curious reference to one of the many experimenters in pith-ball telegraphy, found in "Young's Travels in France," is printed in a recent number of *The Electrician*, London :—

The ordinance was presented to city councils last winter, went to the electrical committee, and by it was referred to a sub-committee. The bill was smothered in that committee.

Another ordinance was introduced after the reorganization of those bodies. The bill was referred to a different sub-committee, received its approval, and also that of the full committee, and came up before common council at its last meeting in June.

When councilman Hartranft, who had charge of the bill, called it up, the startling discovery was made that it was missing from President Smith's desk, and no trace of it could be discovered. It was suspected that certain councilmen who were anxious to defeat the measure had something to do with its disappearance.

A new bill was hastily prepared, but when it came up for a vote it was discovered that the chamber had been set up against it. To give it a future chance, councilman Hartranft voted against it that he might have the right to ask for a reconsideration.

This he did two weeks ago, but the opponents of the bill were still in a majority, and refused to reconsider the former vote.

This very remarkable treatment of an ordinance that was asked for by leading business houses has naturally caused a good deal of indignation in the neighborhood in which citizens were concerned in it, and councils have been denounced unsparingly.

"I am sick of the whole thing," said President Krueger, of the company, yesterday, "and don't want to have anything more to do with councils. We simply wished to put in the lights in order to make a brilliant display in the street and to cheapen the expense. I now have to pay 75 cents a night for my lamp, while it only costs 28 or 30 cents. I suppose the electric light companies were at the bottom of the whole business, as they didn't want us to do the lighting for ourselves. Only arc lights were to be used."

The members of the company are so disgusted with the treatment they have received at the hands of councils that they think of giving up their charter.

Judge Butler, in the United States Circuit Court, listened day before yesterday to the case of the City of Philadelphia against the Western Union Telegraph Co., in which the former seeks to recover $13,000 due from the company in license fees for telegraph poles and wires from 1885 to 1888. Assistant City Solicitor Alexander appeared for the city, and Silas W. Pettit and United States District Attorney John R. Read for the telegraph company. It was argued by the latter that a similar case had come before Judge Hare, in the Common Pleas Court, and was decided favorably to the company.

A verdict for $14,483.43 was given in favor of the city.

At a recent meeting of councils electrical committee the report of the sub-committee favoring the ordinance granting permission to the Western Union Telegraph Co. to use the conduits of the Bell Telephone company was made.

Mr. Hartranft moved to amend the ordinance by adding that the Western Union company be compelled to remove their poles as they occupy the conduits.

The amendment was lost, the yeas being 7 and the nays 7, and the ordinance was ordered to be favorably reported to councils.

Dr. John Wiest, of York, Pa., has invented a storage battery, which, with his improved incandescent electric light, may in time (he claims) become of general use. It can be used in town or country, and each family can run its own battery and make the required electric current needed to light up any building. He has also secured a patent for an electrical heater, which generates heat as powerfully as any steam heater. The doctor is now in communication with one of the large steam car-heating companies, who are negotiating to introduce these electrical heaters into the cars of leading railroads. As a test to show how readily electricity will generate heat the doctor secured an iron pipe, closed at one end, which he filled with broken pieces of carbon, attaching the wire at one end and inserting the wire in the other end among the carbons. These became intensely hot, and a soldering iron inserted among them became so heated in less than a minute as to melt lead when touched. This heat is generated at a very small cost. Dr. Wiest has also invented a paint, a resistant to electricity and fire, which he uses as an insulator. This is applied to wires and electrical apparatus.

It is said that the Fattrell Insulated Wire Co., whose factory is now at Bristol, have been offered five acres of ground at Lebanon, Pa., free of charge, to erect a building large enough for their increasing business.

PHILADELPHIA, October 18, 1889.

BOSTON.

Progress of the West End Company's Electric Car Lines.—Scrip Dividend of the Thomson-Houston Electric Co.—The Thomson-Electric Welding Co.—The Westinghouse New England Agency.—Electric Lighting Notes.—The Boston Edison Company.—Discontent of Cambridge Telephone Subscribers.

FOR some weeks the West End Railway Co. has been engaged in relaying its tracks on Boylston street and West Chester Park, changing from the conduit (hitherto employed on that part of the route) to the overhead system. In doing this the conduit has been entirely removed ; and it was found advisable, as the thoroughfares were torn up, thoroughly to retrack the division. The Longstreet rail was adopted. This rail is of steel, continuous, with a simple wheel thread, without a flange, and has a depth that sinks beneath the surface of the street about nine inches. The base rests at intervals on a broad cast-iron chair which sits on piers sunk deep into the ground, composed of broken stone and cement, and about 18 inches square. The piers, when dry set, are said to be very stable, as solid as the best masonry. Rods of iron bind the rails in place, and are so deep that they do not interfere with the surface pavement. To insure a continuous electric return current should the rails, which are usually relied upon, break, a heavy copper wire is run and buried midway of the rails. The work on Boylston street is nearly completed. Retracking on this principle is being pushed also in the Cambridge division, where complete renovation of tracks is being rapidly carried on, and will probably be extended over the whole of that city in about a year.

The relaying of tracks on Shawmut avenue for the new electric route to Roxbury is on a totally different principle. There the Johnson or Cleveland rail is used. On the surface it shows the same wheel track and flange that is seen on the old rail. The cross-ties of wood are sunk very deep to allow an opportunity for a thick foundation for paving. Upon these rest chairs of wrought steel, bent to clasp and bolt the steel rail, the shoe of which sits into them. The rails are kept from spreading by straps of iron, and under these straps runs the copper wire to keep the continuous return circuit secure.

Beginning November 1, the electric cars of the Cambridge division of the West End company will get their motive power from the Allston power station, instead of from the Cambridge Electric Light Co.'s works, as at present. The last-named company, it is understood, found that its contract with the railway company was unprofitable, and a new contract, agreeable to both companies, could not be agreed upon; therefore, President Whitney decided to take the matter into his own hands.

The fire commissioners submitted resolutions to the board of aldermen adopted by the National Association of Fire Engineers for protection to firemen against the dangers of overhead electric wires. The commissioners earnestly request that the city council give the matter careful consideration, and devise some means to correct existing evils and ward off impending dangers. The communication was referred to the committee on electric wires.

A circular to shareholders of the Thomson-Houston Electric Co. announces that, by vote of the directors, a dividend has been declared payable to the holders of common stock of record, Oct. 5, by a distribution among them of certificates representing undivided interests in certain assets taken from the surplus net earnings of the company. These assets, comprised in what will be known as "Thomson-Houston trust securities—series D," have been set apart in the hands of three trustees to be disposed of from time to time for the benefit of the holders of said certificates. Accompanying is a certificate representing the number of shares in said trust to which each stockholder is entitled.

It is reported that the Thomson Electric Welding Co. recently posted a placard in its workrooms in Lynn asking each of its employés to sign an agreement to the effect "that in case he makes any inventions or improvements at any time, while he is in the employ of the Welding company, relating or applicable to the business of said company, all the said inventions or improvements so made by him shall be the absolute property of said Thomson Electric Welding Co.; and each employé agrees that he will forthwith disclose any such inventions or improvements that he may make to the officers of said company, and assign all patents to the company without other or further consideration than his regular wages or salary as such employé" The employés objected to this, and then the agreement was so modified as to provide that the employés would not be wholly deprived of the profits of their inventive genius. All but five of the employés signed the modified agreement. The men who refused to sign it have been discharged.

The New England agent of the Westinghouse Electric Co. closed a contract with the Hartford Woolen Co., of Hartford, Vt., for a 200 incandescent light plant ; also with the Oldtown Woolen Co., of Oldtown, Me., for a 150 incandescent light isolated plant. The New England office of the company in the Hathaway building will soon have a Westinghouse alternating plant in operation there for exhibition. The dynamo and engine have already been set up in the cellar.

The electric light business during the past year has increased wonderfully in this city, and from 30 to 50 per cent. more electric lights are in use to-day than last fall. One operating company, doing an arc and incandescent light business, supplies current for 4,000 incandescent lights, and, at the opening of last fall, but 2,500 lights were running. About 500 h. p. was recently added to this company's new station to supply the immediate demand. Another company, having two central stations, had 1,300 h. p. capacity for 16,000 lights last fall, and to-day it has a capacity of 2,000 h. p. and has 22,000 lights running.

The increase in arc lighting is very large locally, and many business concerns whose contracts have expired are renewing, and

hotel. The Coates's Opera House across the street from the headquarters of the association has been secured for holding the sessions of the convention, and two commodious halls in an adjoining block have been secured for an electrical exhibit. The halls secured for the display of electrical apparatus will be furnished with current for arc, incandescent and alternating systems. Professor Weeks says the Kansas City electric companies are very enthusiastic, and that the delegates will receive a cordial welcome. The use of the opera house and the halls in which the exhibits will be made, as well as the current furnished by the local electrical companies, will be free of expense to the association and exhibitors.

The Western Electric Co., of Chicago, has commenced an action against the Excelsior Messenger and Cab Co., of St. Louis, to recover for alleged infringement of its call boxes patents.

A. R. Foote, of Cincinnati, who will have charge of the work of compiling electrical statistics for the next census, was in Chicago recently. He thinks that the results of his labor will indicate that the country is better supplied with electrical appliances than is generally believed. He thinks that few persons, even those who are engaged in the business, have anything like a just conception of the progress which has been made in the electrical field. Mr. Foote, in support of this position, casually asks a person to guess how many miles of electric circuits are now operated in the United States, and smiles ironically when an answer is not forthcoming.

The Edison company will supply the electric light and steam plant for the Calumet Club, Chicago; 800 lights will be utilized. The same company will furnish a 300 light increase for the plant of the Chicago Union League Club. The Edison company will also install a 500 light plant in the Hotel Richelieu.

The Electrical Industries Publishing Co., of Chicago, has been organized by Emmett L. Powers, Elmer E. Wood and George H. Bliss. Mr. Powers was formerly the Chicago representative of the New York *Electrical World*. He proposes, it is understood, to publish a monthly electrical paper, to be known as *Electrical Industries*.

D. B. Dean will hereafter be the Chicago representative of the New York *Electrical Review*.

The Electric Light and Power Co., of Belleville, Ill., has been incorporated with a capital stock of $70,000. The incorporators are John Brosius, O. W. Knobeloch and John E. Thomas.

Alfred F. Adams, Alvin W. Walkey and Joseph F. Barton have formed the Union Electric Light and Power Co., of Chicago. The capital stock is $150,000.

CHICAGO, October 22, 1889.

ST. LOUIS.

The United Electric Light and Power Co. Controlled by Philadelphia Capitalists; its Extensive Business; its Several Central Stations in St. Louis.—The Municipal Electric Light and Power Co.—The Suit of the United States Electric Light Co. Against the Heisler Company for Infringement of Patent; it is Likely to be Vigorously Defended.—The St. Louis and East St. Louis Railroad Co. Will Run Electric Cars in November; its Power and Electric Plant.—Other Railway Notes.—The St. Louis Electric Power Co.—A Sprague Plant in Operation.—The Subway Company.—Close of the Exposition.

DURING the past month a controlling interest in the United Electric Light and Power Co. has passed into the hands of Philadelphia capitalists, who are supposed to be identical with the Laclede Gas Light Co. and the Heisler Electric Light Co. of this city. The Laclede Gas Light Co. have the contract for the incandescent lighting of the alleys and city buildings north of Washington avenue after January 1st, 1890; and as they have been moving very cautiously since they obtained this contract with the city, it is supposed that they have obtained these controlling interests with a view of monopolizing gas and electric lighting in St. Louis. While their contract with the city is not a large one—only something like 1,000 incandescent lights—their position for commercial lighting and power is important. Although their contract with the city was closed last March, they made no preparation towards fulfilling it until about six weeks ago, when they began putting in a steam plant on the premises of their gas plant at the corner of Mound street and Levee. The steam plant will be about 1,000 h. p. Heine's multi-tubular boilers, and Williams's triple expansion engines will be used. The Heisler series system will be used for lighting the alleys, and the Brush alternating system for commercial lighting. The selection of these systems was not made public until after the deal mentioned above had been consummated, although it was generally known that the Heisler system would be used in some way.

The United Electric Light and Power Co. was organized last spring, absorbing the following plants:—St. Louis: Thomson-Houston Electric Light Co.; the Thomson-Houston Electric Light Co., of East St. Louis, Ills.; the Brush Electric Light Co., the Metropolitan Electric Light and Power Co. (Hochhausen system), and the Western Electric Light Co., of St. Louis. The Western Electric plant was moved to the Metropolitan station, and now forms a part of Station A of the United Electric Light and Power Co. The station now consists of 3 Buckeye 60 h. p. engines, 2 Ide engines of 60 and 120 h. p. each, and 1 Russell engine of 120 h. p., with adequate steam power. The electric plant embraces 7 Western Electric dynamos, each of 35 lights capacity; 9 Hochhausen dynamos, each of 25 light capacity; the whole supplying some 320 arc lights and about 65 h. p. to arc motors of Excelsior, Baxter and Cleveland patterns.

The Thomson-Houston station of the United Electric Light and Power Co. is the largest station of the United company, having a total capacity of 500 arc lights. The steam plant consists of one battery of 3 O'Brien 18 flue boilers of 500 h. p. capacity, and two batteries, each consisting of two boilers from the Pond Engineering Co., and having a total capacity of 400 h. p. Four different patterns of engines are used. The first and oldest is a Cincinnati slide-valve engine of 200 h. p., only used as a relay. For heavy service (day and night) a Smith & Beggs 250 h. p. engine is used; 4 Westinghouse automatic engines, each of 75 h. p., complete the steam plant. The dynamos are as follows:—4, 35 light; 7, 30 light; and 6, 25 light; all Thomson-Houston standard arc dynamos. The station has been built up in something like a piece-meal manner, starting first with the Cincinnati engine and one battery of boilers about six years ago. A new building, equal in size to the old one, was constructed about two years ago, and the walls of the old building were rebuilt this summer.

The company was very successful, so much so that they were able to effect the formation of the United company; the Thomson-Houston officials being elected to the same positions in the United company.

The Brush station of the United company is the oldest station in the city, and has always done a very prosperous business. The station contains 3 tubular boilers, each of 75 h. p.; 2 Watertown engines, of 120 and 150 h. p.; and 1 N. Y. Safety Steam Co.'s 25 h. p. engine, 1 No. 7, and 6 No. 8 Brush arc dynamos. There are eight circuits, covering 38 miles of wire, and supplying 230 arc lights. Total capacity of the plant, 285 arc lights.

The Municipal Electric Light and Power Co. are likely to substitute the new Wood dynamo in place of the Indianapolis Jenny dynamo, although there is a possibility of another change in plans, as it is no secret that the Thomson-Houston company are at the back of the Fort Wayne Jenny Co., who have lately absorbed the Indianapolis Jenny Co. Their commercial station is now in successful operation, using the Jenny dynamos.

Last August, the United States Electric Light Co. brought suit in the United States Circuit Court, Eastern District of Missouri, against the Heisler Electric Light Co. for infringement of patent No. 306,980, of October 21st, 1884, granted to Edward Weston for a process of manufacturing incandescent lamps. Dickerson & Dickerson, of New York, have filed an appearance on behalf of the defendants. From this it seems that the case will go to trial. As the Heisler company has lately passed into the hands of Philadelphia parties, who are at the back of the Laclede Gas Light Co. and the United Electric Light and Power Co. of this city, it is fair to presume that the fight will not be one-sided, at least so far as financial matters are concerned: These matters, together with the fact that the Paris Universal Exposition have awarded them a gold medal for the highest distinction, make the Heisler people feel very jubilant.

The St. Louis and East St. Louis Railroad Co. will have their cars running by the 15th of November. The power plant consists of an addition to their regular power station for supplying compressed air to the interlocking signals. The electric plant consists of a Jos. Wengler boiler, 66-inches in diameter and 18-feet long, with 22 6-inch flues. The engine is an Ideal engine, from the Ide Engine Works, Springfield, Ills., having a capacity of 125 h. p. An 80 h. p. Thomson-Houston generator will supply the current. The poles are of the lattice pattern, constructed of angle iron, and were designed by Mr. Wuerpel, the mechanical engineer of the bridge company. The bridge company undertake the laying and wiring of the rails and erecting the lattice poles. The rails are wired full length from end to end of each rail, bolted and soldered to the rail at each end, and the two ends of the wires well connected together, and also connected with the iron work of the bridge structure at frequent intervals, so as to make a thorough earth connection. Brownell and Wright of this city are building four motor cars for this company. Total length of line, one mile; grades, 4 per cent. The line will eventually be extended to the National Stock Yards as soon as the street grades of East St. Louis are definitely established.

The electric extension of the Chouteau avenue line of the Lindell Railway Co. is now in successful operation; 10 motor cars are in use. Construction of the overhead work on the Van Deventer extension is being pushed to completion. This company has lately passed into the hands of a local syndicate, who intend to extend the Van Deventer line on to Forest Park.

The South St. Louis Railroad, also the Union Depot Railroad, will equip their roads with the Thomson-Houston overhead system.

St. Louis street car people are not frightened by the Richmond affair.

The St. Louis Electric Power Co., which is the only exclusive power company in the city, have a small Sprague plant of 125 h. p., with 100 h. p. in motors, in use.

The St. Louis Subway Co. suspended work temporarily after finishing the Broadway and Market street sections. This was done to enable the contractor, Mr. Dorsett, to fill an order for ducts for some city in the north. Work will be resumed in a short time.

The Exposition closes to-night. Everything finally got into working order. The Sprague railway had to supply themselves with a generator; the lighting generators on hand were unavailable for their purpose.

The Indianapolis Jenny Co. failed to make an appearance; but in their stead a local dealer made a very good display of two 35 light dynamos, of the Indianapolis Jenny pattern, together with a full quota of single and double lamps.

The electrical exhibition has proven so interesting and successful that the exposition managers are contemplating a continuation of the exhibit at each annual exhibition hereafter.

ST. LOUIS, October 19, 1889.

PITTSBURGH.

Effect in Pittsburgh of the Decision in the Westinghouse-Edison Patent Suit.—The Recent Fire at the Westinghouse Electric Factory.—Street Railway Litigation.—A Comprehensive Electric Railway System Organized for the City.—Thoroughgoing Plans for a Power Station and Line Construction.—Compulsory Burying of Electric Conductors Proposed in Pittsburgh Common Council.

WHEN the decision of Judge Bradley was announced in this city, October 6, dismissing the suit of Westinghouse against Edison, the news created a great excitement in local financial circles. For a day it seemed as if Westinghouse electric stock was doomed for a big drop, but no sooner had the authentic explanations of the case appeared in the daily papers when the former confidence in Pittsburgh electric works were revived, and to-day the sensation is a thing passed and apparently forgotten.

A mysterious fire occurred in the Westinghouse Electric Co.'s building on Garrison alley, this city, a few days ago and the centre building was damaged to the extent of $75,000, including a large amount of stock and machinery. The lamp socket factory, which occupied this part of the building, has since been removed to a neighboring structure, and the contracts for other work have been sent to Newark, N. J., and New York city, the other factories of the Westinghouse Electric Co. Operations were not interrupted during a single day. The burned portion of the old building is rapidly being renewed.

A bill in equity was filed last Friday by the Allegheny Traction Co. against the Federal Street and Pleasant Valley Passenger Railway Co. The plaintiffs state that they have leased from the Citizens' Traction Co. a portion of the old Transverse line, which was leased by the Citizens' company with a right to operate it. The portion leased by the Allegheny Traction Co. includes the downtown end of the Transverse line, also the portion on Sixth avenue from Wood to Liberty street, to Seventh street, and down Seventh street to the North Side bridge. The Pleasant Valley and People's Park Passenger Railway companies, since merged into the Federal street and Pleasant Valley Railway Co., obtained permission from the Citizens' line to run their cars on the tracks on Seventh street down to the bridge.

The defendants now threaten, it is stated, to tear up the tracks on Seventh street and Penn avenue and relay them in their own manner, and have already deposited the material for it on the ground. They never obtained the permission or consent of the Allegheny Traction Co. for this work, and an injunction is asked for to restrain them from proceeding.

The management of the Pleasant Valley Railroad promises that its patrons shall be transported to Thanksgiving Day services by electrical cars. The conversion of the several lines owned and operated by the company from the old-fashioned *mule* car tramways into modern rapid-transit lines, operated by electricity, is progressing rapidly.

When the conversion is effected, if the plans under which it is being made are followed out, the new system, in the estimation of experts, will be the most perfect and best equipped in existence. Every device known to railroad construction, electrical seience, engine and car building, that will conduce to the comfort, convenience, safety, and to rapid transit, is being employed.

Work upon the super-structure of the big power house at the outer terminus of the main line in Pleasant Valley, was commenced early this week, and is being pushed rapidly to completion. Here all the power for operating the three lines, the Federal Street and Pleasant Valley, the People's Park Passenger Railway, and the Observatory Hill Road will be generated, and from it will be distributed. This power house will contain the two Hazelton Tripod boilers, each 45 feet in height, exclusive of the bases and stacks; the two 500 h. p. and one smaller 250 h. p. engines, together capable of doing just four times the work that it is estimated they will be required to perform for many years to come.

The engines are in nowise singular, except in respect to size and power, but the boilers are unique. They are upright, and when completed will tower 72 feet in the air. Protruding from each are 1500 water tubes, each 3x15 inches, and each boiler will be encased by a shell of brick, inside of which the flame from the furnace will ascend. Coal slack will be used for fuel, and a smoke condensing apparatus will be employed, which will render the furnaces absolutely smokeless.

The system of roads will be divided into eight sections, to each of which power will be transmitted direct; each with its own switch-board. An accident on any one section, while it will stop every car that may be upon that particular section at the time, will in nowise interfere with the operation of the seven other sections. But to meet emergencies of this nature, a wagon equipped with electrical apparatus, repair tools and instruments of all kinds, and manned by a crew of skilled repairmen, will be kept on duty constantly at the power house, and should a hitch occur on any part of the line it can be despatched there, and, unless the trouble be of a serious character, can have the section in operation again in a few moments.

Danger to life by electric current has been amply provided against. The insulation of the big feed wires through which the powerful current will be transmitted has been made perfect; but in addition to this provision the tops of the iron masts on which they are carried are of wood coated with sulphur, constituting a perfect non-conductor, on the tops of which, in turn, will be glass insulators. The trolley wires over the tracks are suspended from the transverse feed wires by means of mica bells, and should one of them be broken and drop to the ground, the current will stop at the bell. By means of these precautions the danger to life is reduced to a minimum.

At a meeting of select councils, this city, held last Monday, the Birmingham Traction Co. obtained the necessary franchise for laying its cables and tracks along Carson street, south side. The road will now be built at once, and the management expects to have its cars running by next spring.

On the same day, common councils had a discussion about the advisability of putting the electric light wires underground. A resolution was passed to make it compulsory for the wires to be put underground. This includes the telegraph, telephone, police and electric street car wires. The resolution was referred to a special committee. Should such an ordinance be passed, the Federal Street and Pleasant Valley Railway Co. will have to change its overhead system, and convert it into the conduit system.

PITTSBURGH, October 17, 1889.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *150 Broadway, New York city.*

THE RIGHTS OF INVENTORS—THE LAW.

I.

[111]—After an invention is fully completed by a reduction to practice, the law allows it to be used in public or sold during the ensuing period of two years before the inventor will forfeit his right to a patent; *provided that at any time before the expiration of this two years of public use or sale, the inventor makes an application for a patent.* (Sects. 4,887 and 4,920, Revised Statutes of the United States.)

It will be observed that the law does not make it imperative that the inventor *shall obtain* his patent during the two years of allowed public use and sale, *but only that he shall make his application therefor during this period.* After the application is once filed in the Patent Office, the inventor can keep his pending application alive for an indefinite period by amending it once in every two years. (See sect. 4,894, Rev. Stat., U. S.)

But this amendment may be wholly a formal matter, which can be wholly ignored and left out of the patent—whenever the inventor is ready to take out his patent. Such an amendment may be made (if the inventor so desires) for the sole purpose of keeping the application alive. So, if an inventor wishes to keep his pending application alive in the Patent Office, and deems it to be for his interest not to take out his patent immediately, in such cases especial care should be taken to so amend the application that the patent will not be prematurely "allowed."

After the application for a patent is once "allowed," the inventor must pay the final government fee of 20 dollars and take out his patent within six months after that date; else he forfeits his pending patent application and the first government fee of $15 already paid. (See sects. 4,885 and 4,887, Rev. Stat., U. S.)

The inventor, in such case, may, however, file an entirely new application for a patent, provided his right to a patent is not barred by the two years of public use or sale before spoken of.

It is, therefore, evident that the inventor by proper management, can keep alive his legal right to a patent for an indefinite period; and this notwithstanding the invention may have been on sale or in public use for over two years before the grant of a patent.

II.

The scope and value of letters patent are almost invariably misapprehended by inventors until they have learned to form a proper judgment of such matters by what is often a ruinous experience in patent litigation in the Federal courts.

A patent is certainly no guarantee that the inventor is lawfully entitled to the monopoly sought in the claims of the letters patent. A patent simply and only gives its owner a right to commence suit against an infringer. If the infringer succeeds in proving that the patent is invalid, then the suit fails. On the other hand, if the court sustains the patent, the infringer is compelled to pay over all his ill-gotten gains and profits.

But this right to sue has no real value until there is an infringer. Infringement is one of the very best evidences of the money value of a patent. No one will assume the unprofitable trouble of infringing a patent which is commercially worthless. It often requires 5, 10 and even 12 or more years to get a really valuable patented invention introduced to the public and made valuable to the owner.

During all this long period of trial and experiment the lifetime of the patent is thus needlessly spent, and the monopoly, then for the first time made valuable, has already lived the most or nearly all of its 17 years of life.

Now if the patent is only allowed to commence to run after the value of the invention has really been proved by a successful public use and sale, then, and then only, would the inventor have the full 17 years of the life of the patent in which to reap his harvest—a harvest not till now ripe for the sickle of the patent owner.

On the other hand, if the invention did not prove to be profitable, the inventor would not pay the second government fee of $20, and take the patent out of the Patent Office.

Guided by such intelligent action, the problem about the granting of worthless patents would then be solved, not only without loss and disappointment to inventors and manufacturers, but to the entire satisfaction of both of those two classes, as well as other patent owners.

Manifestly, then, the inventor's interest, as a general rule, will be best served by allowing his patent application to remain in the Patent Office as a pending application, until he has got his invention introduced, and proved its value, and until the infringer begins his travels.

Of course there may be, and often are, special reasons applicable to particular cases, why the issue and grant of a patent may be desired with no more delay than is actually necessary, in order to carefully examine the state of the art to which the invention belongs, and to properly word the specification and to limit and shape the claims. But when this fact exists, the matter can be fully explained to the inventor, so that he can correctly understand the case in all its bearings, and thus decide intelligently what his true interests demand.

Most inventors (whose patents have proved to be valuable) have, however, learned by very dear experience that it would have been far better for them to have kept their applications alive and pending in the Patent Office, and not to have taken out a patent until the invention had become profitable.

These statements of law and practice have been made on the hypothesis that the applicant for a patent only desires his patent for an honest and a legitimate purpose, and that he has confidence that his invention is a really meritorious one. If the applicant for a patent desires it to palm off on to some unsuspecting purchaser, ignorant of the scope and value of a patent; or if he desires the patent in order to fleece the public before any one dares to question its validity by infringement; or if he desires the patent only as a scarecrow to other manufacturers, keeping them off by bold threats of a costly infringement suit (which most men do not dare to risk); if, for these or other similar reasons, an applicant desires the grant of his patent with all haste—then the foregoing advice and suggestions are of no value whatever.

If this plain statement of facts serves to put inventors and the owners of patent interests on the inquiry regarding their rights and interests in patent matters, then the object of the writer will have been fully accomplished. JOHN McCLARY PERKINS.

Boston, Mass., October 14, 1889.

LITERATURE.

A Dictionary of Electrical Words, Terms and Phrases. By EDWIN J. HOUSTON.

It would be difficult to mention a work of reference of any kind which has during the past few years been more urgently needed than a dictionary, or rather a cyclopædia, covering in an adequate manner the extensive field of theoretical and applied electricity. The industries dependent upon this remarkable agent have of late assumed an extent and importance far transcending the most sanguine prophecies of a decade ago. Hundreds of millions of dollars are invested in electric lighting, power distribution, telegraphs, telephones, submarine cables, and countless subsidiary industries, in which great numbers of persons find congenial and profitable employment, while a vast mass of professional and technical literature has grown up having to do with this class of subjects. The larger portion of this work, especially the industrial part of it, has been accomplished by the English speaking races, and yet, prior to the appearance of Professor Houston's dictionary, no attempt, so far as we are aware, had been made by any one to supply the demands necessarily created for a work of this character.

In undertaking an alphabetically arranged treatise covering so wide a field a question of no small difficulty presents itself at the very outset in reference to the general plan and scope of the work. A mere catalogue of all the terms used in electrical literature, accompanied by definitions, however complete and well executed it might be, would be at best of but limited usefulness, either to the layman or to the professional electrician; while, on the other hand, an encyclopædic treatment of each of the subjects, which would necessarily fall within the scope of such an undertaking, would so increase its bulk and enhance its cost as to place it practically beyond the reach of the very class of persons who might be expected to derive the greatest benefit from it. Then again, ought such a work to be principally addressed to the tyro, the student, the theorist or the practical electrician? These are questions much more difficult to answer rightly than would at first appear, but they relate to matters which deserve, and must perforce receive, the most careful consideration.

The author in his preface modestly disclaims any transcendent degree of credit for his labors; and hence we may fairly take him at his word when he states that he offers his dictionary as a starting point only, and cordially invites the friendly criticism of his professional brethren.

That Professor Houston's work, as a whole, is one of very great merit, will be obvious to any one, even upon the most cursory examination. The general plan of treatment adopted is one which partakes in varying degrees of the characteristics both of the dictionary and of the cyclopædia, the best no doubt which could have been employed, but so difficult of execution in detail that it is no disparagement to the author to say that he has not always succeeded as well as could have been wished in the handling of some of his topics. Professor Houston is an instructor of reputation and success, and, as might be expected, is at his best in his theoretical definitions and explanations, such, for instance, as in the discussion of units of measurement, characteristics of electrical energy, and the like. Excellent examples of his ability in this direction may be found in his explanatory definitions of such terms as "potential" and "electro-magnet," which leave little opportunity for improvement in the way of brevity, clearness and accuracy. But he is obviously much less at home among the large class of subjects which have to do with the practical and industrial applications of his favorite science, and his treatment of many of these topics leaves much to be desired.

In view of the fact that the vocabulary is the first of its kind which has been compiled in our language, we have found it unexpectedly complete; there are, nevertheless, as might be expected a considerable number of omissions, to some of which we shall have occasion to refer further on, but we will say here that, in pointing out these and other errors of omission and commission in Professor Houston's work, we shall do so, not in the least spirit of unfriendly or captious criticism, but with the honest intent to indicate certain particulars in which it appears to us to be susceptible of improvement, feeling sure, as we do, that a revised and enlarged edition must be imperatively called for in the near future.

Considering the work as a whole, its most obvious defect appears to us to be the inadequacy of the treatment given to many subjects of importance, an inadequacy which is aggravated, in not a few instances, by the infelicitous distribution of what is properly a single topic under various disconnected heads; in fact, the arrangement of the subject entries throughout is not only illogical, but amateurish to a degree, which, if it were only less exasperating, would be excessively funny. For example, we have "Electric Alarm (see Alarm, Electric)," "Electric Buzzer (see Buzzer, Electric)," "Electric Clock (see Clock, Electric)," and so on by the page together, including even such entries as "Electrical Death (see Death, Electrical)." This fault really detracts seriously from the convenience of using the book, and ought by all means to be remedied in the next edition by submitting the matter to the revision of a skillful professional indexer. To show how it works:—Suppose one should desire to investigate the principle of the Dial Telegraph. The cross-reference says, "see Telegraphy, Step-by-Step." Under this head we are again referred to "Telegraphy, Needle or Dial," only to find that there is no such entry as "Telegraphy, Needle, or Dial," the subject being treated under the alphabetically placed head of "Step-by-Step Telegraphy," where few persons would think to look for it in the absence of a cross-reference.

The great electric industries of telegraphy and telephony receive but scanty consideration in view of their position as two of the most important factors of modern civilization. The descriptions of the apparatus are very brief and wholly insufficient to convey an intelligible idea of the subjects. Terms and phrases which are in constant and familiar usage in the telegraphic service, such as "insulation resistance," "conductivity resistance," "resultant fault," "constant of galvanometer," "adjustment" (in its technical sense), and many others appear to have been wholly overlooked, and are conspicuous by their absence. Even a subject of so great theoretical interest and practical importance as quadruplex telegraphy is dismissed in twenty words, although more than five pages are devoted to Delaney's synchronous multiplex system, which, so far as we know, is not employed in this country at all. The remarks on the telephone are very meagre, although the author improves the occasion to assure his readers that the articulating telephone was invented by Reis in 1861. Most persons who have tried it will, we imagine, incline to regard Reis's apparatus as most emphatically a *non*-articulating telephone. The omission of the slightest reference to such extensive electrical enterprises as the exchange quotation, or "ticker," service; the district telegraph messenger, and central station burglar-alarm systems; the electric railway signal service; and the transmission and distribution of electric power, is, moreover, scarcely excusable in a work of this kind.

Other words and phrases which have occurred to us as being entitled to a place, but which have failed to secure one, are such as "Inductive Circuit;" "Translating Device," as a synonym for electro-receptive device; "Plant;" "Kerite;" "Load;" "Mile-ohm;" "Specific resistance"; while on the other hand it is not apparent by what principle of inclusion such terms as "Audiphone," "Phonograph," "Phosphorescence," and the like should occupy space in an electrical dictionary which might be employed to better advantage. Such definitions as "Electrical Death" and "Electrical Execution" might also have been omitted without disadvantage.

Of absolute errors, the work apparently contains but few. It is more than doubtful if the acoustic sounder was invented by Morse, as stated on page 10; at all events it would seem appropriate in a work of this kind to avoid, so far as possible, dogmatic statements as to who was the inventor of this or that. The European telegraphic code is referred to on page 20 as the "Continental," when "International" is doubtless meant. "Shackling," referring to a telegraph wire, is misprinted and wrongly indexed as "Stackling" on page 10 of the appendix.

We have referred to the insufficiency of many of the definitions, which have to do with the practical as distinguished from the theoretical side of electrical engineering. A few examples, selected at random, will serve to illustrate our meaning:—

Capacity of a Cable.—The electrostatic capacity of one conductor of a cable as compared with the capacity of the other conductors grounded.

Collectors.—The metallic brushes that rest on the commutator cylinder, and carry off the current generated on the rotation of the armature. Collectors are familiarly called commutators.

Telegraphy, Diplex.—A method of simultaneously sending two messages in the same direction over a single wire.

Other definitions are vague in their phraseology, and hence more or less misleading to the student, as, for example:—

Conductors.—Substances which will permit the passage of an electric current through them. This term is opposed to non-conductors, or those which will not permit the passage of an electric current through them.

Of course no one knows better than Professor Houston that there is no such thing as a non-conductor, and he would have done well to have pointed out to the student that the distinction is a purely relative, and not an absolute one.

Source, Electric.—Anything which produces a difference of potential or an electromotive force.

The term necessarily implies the *maintenance* of a difference of potential as well as its establishment.

Ohmic Resistance is a term which, although sometimes employed by no less an authority than Sir William Thomson, ought to be incontinently ejected from electrical literature. As George Prescott once forcibly remarked, "one might as properly speak of the 'feetic length,' or the 'poundic weight,' of a piece of wire as of its 'ohmic resistance.'"

Average Electromotive Force—The mean value of a number of electromotive forces of different values.

Why not have said "the sum of the values of several different electromotive forces divided by their number?" A mean and an average value are not necessarily the same.

But it would be easy to continue this kind of criticism too far. Where so much of the work is undeniably good, and so little is positively bad, we should be very sorry to run the risk of creating an unfavorable impression by elongating the catalogue of minor faults, from which the most painstaking cannot expect to find himself wholly exempt.

The mechanical execution of the book calls for both commendation and criticism. The paper and typography are of excellent quality, but the reader is undesirably and unnecessarily exasperated by the absence of the usual catch-letters at the top of the pages, and because the book is so bound that it cannot be made to stay open (at least our copy will not), two serious faults, particularly in a book of reference. The illustrations are fairly numerous, though a good many more might have been introduced with manifest advantage, particularly as many of the existing ones are merely pictorial and not in a proper sense illustrative of the text. In quality of artistic execution, moreover, many of them are scarcely up to the standard we have been taught to expect at the present day in a work of this character.

We are pleased to learn that the Dictionary is meeting with a most cordial reception at the hands of the profession, and we trust that the publishers and the author may receive the substantial reward which their praiseworthy enterprise so well merits.

Modern Views of Electricity. By Oliver J. Lodge.

Students who are able to read and thoroughly understand the mathematics of Maxwell, have arrived at some idea of a mechanical theory of electricity, but there are very few who will derive a clear conception of electrical action by manipulating mathematical symbols, and not many who would reach any but the vaguest notions of electricity without the aid of illustrations drawn from phenomena with which they are familiar. Lecturers upon and teachers of science find it necessary always to appeal to phenomena easily seen and comprehended to lead the imagination to grasp the unseen motions that are the basis of most of the phenomena with which science has to deal. The kinetic theory of gases is illustrated by the impact of elastic balls; vibratory motions giving rise to sound and light are illustrated by vibrating pendulums, by reference to water waves, and by a great variety of special apparatus in which the movements are of such magnitude and at such a rate as to be easily followed by the eye. In polarized light, models and sections of waves must be presented to help the student to picture the minute motions of which he can see only the effect. In sound and light the lecturer has had provided for him a wealth of illustrative apparatus and models which help him to lead the student up to a clear conception of the basis of these phenomena. But when it comes to electrical phenomena teachers have generally had to be content with presenting facts and a very few generalizations linking together a few closely related phenomena.

The developments of Maxwell and Thomson and other mathematicians, by which all electrical phenomena and optical phenomena as well were brought under one general theory, were a sealed book to most students because of the mathematical language in which they were presented. In the little book before us, Dr. Lodge has endeavored by means of mechanical illustrations which all can comprehend, to present to the reader something bearing a very close analogy to electrical phenomena. All such illustrations whether they represent the real causes of electrical phenomena or not are a great help in presenting the subject, for a phenomenon ceases to be incomprehensible as soon as we see an analogous phenomenon produced in an easily understood way. The continuous cord fastened to elastic partitions shows at once how we may regard the strain in the dielectric, and the explanation of the residual charge becomes at once apparent. It is clear also why the discharge should be a vibratory one where it takes place through a good conductor, and why there should be but one discharge when the conduction is imperfect.

The "hydraulic model of the Leyden jar" is a most valuable illustration as it enables one to produce by means, every step of which can be easily followed, changing pressures entirely analagous to those presented by the Leyden jar.

The representation of a magnetic field as a series of toothed wheels gearing into each other, is certainly very ingenious. It accounts for the magnetic lines around the conductor and shows that the transmission of energy through the dielectric and not through the conductor, is at least thinkable. One imagines, however, that to most people it will be a somewhat startling statement that the conductor takes no part in the transmission of energy but is merely a means of separating a certain area from the space around, and so permitting the magnetic spin within the enclosure, and still more startling, probably, is the statement that, if the conductor were perfect, not merely is no energy spent in it, but nothing whatever takes place within its substance.

But while the toothed wheels afford us a conception of the transmission of energy by means of the dielectric, it is not so clear how magnetic forces are accounted for. The author, on page 203, ascribes the movement of a conductor in a uniform field to an "extra centrifugal force on one side." This will require that the wheels be elastic and become larger as they increase in velocity, and this makes the structure a very complicated one. In fact the alternate positive and negative wheels so engaging with each other that rotations of one set are all in one direction and of the other set in the opposite direction, form a very complicated system.

General readers will be very thankful to Dr. Lodge for helping them to some sort of conception of the ultimate composition of matter and the activities that give rise to various phenomena. Luminous phenomena are shown to be only manifestations of certain forms of electrical activities, and enough is given to show that the imagination may soon be able to link together all the

various manifestations of energy and make them appear as comparatively simple movements in all an pervading medium.

The Voltaic Accumulator. An Elementary Treatise. By ÉMILE REGNIER. Translated from the French by J. A. BERLY. London and New York: *E. & F. N. Spon*, 1889.

THIS book, by the well-known author of "Piles Electriques et Accumulateurs," was published in the original French in the early part of 1888, and at that time contained a fairly complete exposition of the inventions and applications of electric accumulators. The improvements which have been introduced in this branch of electrotechnics, particularly in England and the United States, during the past two years, have been so radical and important, however, that the book can hardly be considered up to date at the present time. This criticism, nevertheless, in no way applies to that larger portion of the work which is devoted to a careful explanation of the fundamental principles underlying the actions of voltameters, and their progeny, the various elementary forms of accumulators; indeed, as a history of the evolution of the accumulator, excepting the most recent practical types, the book is replete with information.

The subject-matter of the work is conveniently arranged in four parts, the first part being mainly concerned with general principles, wherein, after a chapter on definitions, there is one devoted to voltameters or primitive secondary cells, which covers the ground very thoroughly; and it is interesting to read here that although Carlisle and Nicholson, while experimenting upon the electrolysis of water, unwittingly constructed an apparatus resembling an accumulator, it was Gautherol, in 1801, while electrolyzing salt water, with platinum and with silver wires, who first discovered the existence of secondary currents. We also learn that a little later on, Ritter constructed a secondary battery made of metallic disks separated by cloth washers, and that Volta, Marianini and Becquerel demonstrated that these currents have a chemical origin; but although Matteuci obtained currents from platinum strips, previously dipped into oxygen and hydrogen, and Grove devised his celebrated gas battery, it was not until Planté, in 1859, discovered the properties of lead voltameters, that there was any indication of the practical utility of the accumulator. Similarly, we learn later on, that no industrial value was attributed to the accumulator until Faure's important invention revolutionized the process of manufacture. The first part of the work ends with a classification of accumulators into four genera or species.

The second part of the book is devoted to the description of various types of practical accumulators which were known at the time. Planté's original secondary cells, of course, receive their merited attention, and the chemical reactions which occur in them are duly set forth. The various modifications of the Planté element are divided into two classes, those having both electrodes prepared from homogeneous substances, and those in which the materials are heterogeneous. To the former belong the Tommasi, Kubath, Simmen and Regnier accumulators, and to the latter the Faure type and all of its modifications, as exemplified in the improved Sellon-Volckmar grid or support plate, changes in the composition of the liquid or oxide by Phillipart and Tribe, and by the cells of Regnier, Farmine, Fitzgerald, and others. This portion of the book as well as the remaining chapters of the second part, which treat of miscellaneous accumulators of the lead-copper, lead-zinc, and alkaline copper-zinc classes, is perhaps chiefly interesting in its historical aspect. Yet there is much useful data respecting the dimensions and capacities of the various types of cells described, to be found in this part of the work; and while the author allows the respective inventors to make opposing claims in some instances, he has endeavored, as he states in his preface, to select for description only such cells as present distinctive characteristic differences.

The third part of this work treats of technical generalities concerning the actions of accumulators. Several charts showing the curves of discharge for potential, current and energy are given, and also some figures relating to the efficiency and life of accumulators. Very little specific information regarding the maintenance of accumulators under the various conditions of use is, unfortunately, to be found there; and it is equally to be regretted that part iv., which concludes the work, treats only in a general way of the practical applications of accumulators. It is doubtful, however, whether more explicit directions regarding the installation of accumulators, as practical at the time this book was written, would be of much service at the present time.

As to the translator's work, the less said the better. Every page bears evidence to his unfamiliarity with his subject, however well or ill acquainted he may have been with the French and English languages. Proper English equivalents to many French words are not employed, and many sentences are grotesque or absurd; while throughout the book there is hardly a paragraph which could not have been expressed in a clearer and smoother style.

.... LIGHT is merely a series of calorific indications sensible to the organs of sight, or *vice versa;* the radiations of obscure heat are veritable invisible radiations of light.—*Melloni.*

CATALOGUES AND PAMPHLETS RECEIVED.

From the Electrical Supply Co., Chicago, comes an uncommonly handsome Catalogue, No. 560, Electric Light and Power Supplies. The size of this catalogue—322 pages octavo—is suggestive of the extent and multifarious demands of the business of furnishing electric light and power and of the business of manufacturing the apparatus required for carrying it on. The Electrical Supply Co. take for their province nothing less, it would seem, than the whole field of materials and supplies—burning iron, castings and wood-work required in the manufacture or operation of electric light and power plant. Their catalogue presents a list of their wares in convenient and attractive form, with ample illustrations and abundance of descriptive or explanatory matter. The illustrations are unusually good; the plates showing incandescent lamp shades and arc lamp globes; pages 102-104 being particularly fine.

RECENT PUBLICATIONS.

Electricity in Our Homes and Workshops. A Practical Treatise on Auxiliary Electrical Apparatus. By Sidney F. Walker, M. I. E. E., etc. London: 1889. *Whittaker & Co.* New York: *D. Van Nostrand Co.* Cloth, 316 pp., illustrated. Price $1.50.

Alternate Current Machinery. By Gisbert Kapp, Assoc. M. Inst., C. E. Reprinted from the Minutes of Proceedings of the Institution of Civil Engineers, London. Van Nostrand Science Series, No. 96. New York, 1889: *D. Van Nostrand Co.* 18mo., boards, 199 pp., illustrated. Price 50 cents.

Practical Electric Bell Fitting: A Treatise on the Fitting up and Maintenance of Electric Bells and all the Necessary Apparatus. By F. C. Allsop. London and New York: *E. & F. N. Spon*, 1889. Crown, 8vo., 142 pp., illustrated.

NEWS AND NOTES.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF OCTOBER 15, 1889.

The 38th meeting of the Institute was held in Professor Doremus's Lecture Room at the College of the City of New York, October 15.

Mr. Franklin L. Pope was elected chairman.

The Chairman—Ladies and gentlemen: We are to have the pleasure this evening of listening to one of our most esteemed members who has spent his vacation, I hope pleasantly and profitably, in examining matters of electrical interest on the other side of the Atlantic. Mr. Lockwood,—whom you all know very well by his writings, and many of you personally,—has had the distinguished honor, among other honors, of having a portion of his works translated into the Japanese language, so that his fame has reached at least half-way round the world. Since I last had the pleasure of meeting my fellow members I have made a trans-atlantic trip myself, and therefore shall have an opportunity to try Mr. Lockwood by the true test of all greatness and wisdom, and that is whether one agrees with you or not.

Mr. Lockwood will now deliver his address on "Electrical Notes of a Trans-Atlantic Trip."

Mr. Thomas D. Lockwood—Mr. Chairman, ladies and gentlemen: In addition to what has been stated about the distinguished honor that I have experienced of having a portion of my writings translated into Japanese, I would like to say for the benefit of the audience that I am still further honored in the presence of the translator with us this evening. Before I read this paper I think I may say further that the chairman's ideas of European manners and customs are undoubtedly correct. I am quite sure I shall agree with him.

(For Mr. Lockwood's paper see page 476).

DISCUSSION.

The Chairman—We have listened with much pleasure, not unmixed I hope with profit, to Mr. Lockwood's interesting paper. In no way is there more to be learned than by comparing with our own the work of other countries, work done by men engaged on the same problems as ourselves, but on their own lines and under different conditions. From Mr. Lockwood's remarks about the English telegraph service, I am reminded of some features of it which struck me as exceedingly convenient. One of them is the method of pre-paying telegrams by stamps. The rate is sixpence for 12 words, counting the address and signature. Each additional word is a half-penny, and the ordinary postage stamps are used indiscriminately, for letters and telegrams. The convenience of this appears, as it did to me two or three times when traveling a long distance on an express train, which sometimes does not stop for two or three hours. Having occasion to send a telegram for some one to meet me at a point ahead, I have written my message while on the train, put stamps on it, wrapped up three or four coppers with it for "backsheesh," and thrown it off at a way station, and I have always found that it was despatched and in due time received at the point of destination. That is a very great convenience. There is another feature that will strike our people as a little curious, and that is that in English telegraphing there are no dead heads. If Mr. Preece sends a telegram he has to put stamps on it, and if Queen Victoria sends a message, she also has to put stamps on. Office messages are sent by mail and paid by postage stamps.

Mr. Lockwood has referred to the construction in England,—the careful manner in which the poles are stayed. That is very

highest houses we could and blocked them, and they did the same to us. Of course it ended as most of those things do. The United Telephone Co. bought the other company out, and most of the wires were afterwards taken down. Then we come to another point, what we call "leading in"—that is, taking the wire from the pole to the office of the subscriber. In England that is always done with gutta-percha covered wire. The people who began telephone work in England were those who had had a little to do with telegraphs. This wire costs about three or four pence a yard. It has a thick covering of first-class gutta-percha. Of course this insures immunity from faults and leakage, and it is in some cases taped and in some cases braided. But if it is taped it is very strongly taped, and the whole thing is what you can call a very excellent job. One great reason, perhaps, why tramways have not made more advance in England is that posts are not allowed in the streets. Probably in the country districts they might be allowed, but without a lot of formalities, etc., before town councils, no leave to put up posts will be given. I think it is highly probable it will come, but still it will take time. On the other hand, notwithstanding what has been said about electric railways here—I know perfectly well you have nearly a thousand miles in operation—I have just come from San Francisco; I stopped in San Francisco some days; I stopped at Denver and Salt Lake City and at Chicago and at Pittsburgh and at Philadelphia, and I have been here some days. At each of these places, I have done all I could to see electric tramway work. I happened to see a car in the distance at Salt Lake City. They were putting up the wires in Pittsburgh. I was kindly shown a car running with accumulators here yesterday. I called on the Sprague company and they said they had nothing which they could show within a hundred miles of New York, so that although you have a great deal, yet your country is so large and the work is so scattered about, that it does not show much, and I think perhaps the same applies to England. We certainly haven't got anything like that length of track, but there are a lot of little tramways running about there which I think may be called to some extent the pioneers of tramway work. For instance, there is the Blackpool tramway which has been running several years. There is the Port Rush tramway in the north of Ireland, which I think was the first electrical tramway ever erected. There is a small tramway running along the Brighton Beach which is very popular. That has been running six years. There are two or three companies in England operating experimental lines now in a small way, and certainly without going out of your way to see them you probably would not succeed in doing so. I had thought that perhaps Mr. Lockwood would have seen the new underground railway which runs from the Monument in the city to the Elephant and Castle, about three miles distant on the other side of the river. That is one of the most interesting engineering works which has lately been accomplished in England. You all know something about the underground railway, which corresponds to your overhead railway here. Your elevated railway is certainly very efficient and very cheap. Ours is very expensive and some people say very nasty, but it answers its purpose and you don't see anything of it. Well, the new underground railway in London starts from the Monument and goes right under the bed of the river at about 20 feet depth, and so far under the foundations of any houses that it has not been found necessary to compensate the owners. It goes about 60 feet under the houses. At the Monument there is a station with hydraulic lifts. I am not aware whether it is actually running or not, but it is nearly finished if not quite so. At each station there is a series of lifts, by which the passengers go down or come up. From these two tunnels are driven through the ground starting away to the other end of the line. This railway will be operated by electricity. The firm of Mather and Platt, of Manchester, undertook to furnish the whole of the electrical plant and run it for a term of years at a price which I believe—at least I take this statement from the papers—was considerably less than what it would cost the underground railway company to work their locomotives by steam, and as Mather and Platt are a very large concern—who, by the way, make the Edison dynamos in England, as well as the Manchester—no doubt they are prepared to stand the racket if it does not succeed. But I think that it will be a very interesting application. Mr. Edward Hopkinson is their electrician.

Passing on to electric lighting, beginning with the station at the Grosvenor, we were working with 2,500 volts; and the dynamos were so perfectly self-regulating, at any rate when I was there, and with the load they had on them, that all regulating appliances were practically unnecessary beyond a sensitive governor, perhaps an electric governor, on the engine and something to keep the exciter in order. All you have got to do is to keep your dynamo turning round at the same rate. The circuits were so large that the putting on of lights or taking them off practically made no difference, and we always arranged things in this way, that we never allowed, if we could help it, at any rate, any large circuits to be run in public buildings or theatres or anything like that. That is to say, we always contrived that not more than 50 or 60 lamps should be turned off at the same time. Of course a man going around a building could turn off four or five switches, but while he was doing that the engine driver would have a chance to look around. The circuits were so large that 50 or 60 lights on or off practically made no difference, and most of the regulation was simply done by the engine driver standing near his engine when the curve was going up.

The overhead work is done on very much the same line as telephone work, only the poles are shorter, sometimes they are not more than 12 feet, but as a rule they run to 18 feet. Near the top of the pole is a clip, and an insulator is secured to this by a strap and nut, as was formerly done in telephone work. From here to the next pole which might be as much as 100 yards away, but preferably not more than 60 or 70, a steel suspender of seven No. 14 gauge wires is run, and that is bolted up pretty tight. I might say it is an extremely nasty job to the men making up these steel suspenders—turning the things around to make a good tight way-leave job. Below there was another similar insulator and to this the cable was made fast. The cable ran right along below. Most of the main circuit cables were 19 No. 15 gauge, the branches being about seven No. 16's, and so leading off to seven No. 20's, or something like that for a few lights. You will see that, first of all, this steel suspender is absolutely insulated. That suspender will practically stand almost any voltage you could put on it. The cable itself was insulated in the same way. Supposing it was a bare wire there was always three inches of china between it and the nearest earth. These cables were first of all insulated with little ebonite rings by which they were suspended, having a little split ring which allowed them to run along the suspender. Afterwards Mr. Ferranti adopted raw hide leather thongs which were slipped over the cable. The cable was all wound up on a barrel or any convenient means. This cable was taken up to the pole, the first ring put on, and the cart taken to the next pole. If you were going to run half a mile of cable you would have a man to almost every pole. They would haul the cable, the men putting on the rings as it went by. Of course it is a slow process, but it is fairly satisfactory when it is done. First of all, you have the insulation of the cable; secondly, you have the insulation due to the raw hide thong; thirdly, you have the insulation due to the suspender, so that altogether you are fairly safe. Supposing that suspender goes; the cable at first is bound round the insulator quite firmly enough. It is no good spending a lot of money on insulation and getting tests in a test room, if you spoil it before it is up. But in this case, these insulations were due to the cable that was wound around them and lapped across, so as to avoid as far as possible cracking the insulation in any way. Therefore, unless the pole came down bodily, there was not much chance of an accident happening, and if the pole came down bodily, this insulation as has proved to be the case in more than one instance, would be quite sufficient to keep everything right until the fault was remedied. There is another advantage in having this suspender. Our poles were usually lower than telephone poles The steel suspender the telephone people were at liberty to draw their wires across as much as they liked. Occasionally they would get a wire underneath, and when it was sagged, haul it a few minutes, but they soon learned to leave off doing that. In fact, I have seen a coil of telephone wire with the little pittings, which, as you know, result from the arc.

The second circuit came under in the same way, and it was a point of good workmanship amongst the linemen that the sag on the two wires should be the same. I fancy people here do not bother their heads at all about that. In England if an employer saw one wire sagging and another caught, the probability is that the foreman would be dismissed. Of course, working with the alternating current and on a parallel system we have no confusion of wires such as there is here. A single circuit was mainly sufficient for most of the requirements. In a few instances where lines were going into different districts, owing to difficulties in getting our leaves, there might be four wires, but not more. I put it to American engineers whether this is not really the way of doing things. The number of circuits you get by running arc lamps or anything else in series, becomes in time stupendous, and I know in working in telephone work underground what a bother it is to be mixed up with conduits, and the remedying of faults. In adopting a parallel system, you get rid of that and you get simplicity right away. When we wanted to take the current off, we put on another set of insulators, and we took what we call "T's" out of the cable at a few feet from the post. These, of course, were small wires; they were carried down the side of the house; the insulators standing well out from the wall, and as a rule they went through the walls in china pipes, especially made for the purpose; that is to say, we do not simply take a chisel and ram a hole through a wall anyhow, and just put the wires through as I saw them doing in Pittsburgh. It was rather a costly job I must say. We finished up with Portland cement afterwards, the wire coming to a cut-out, which by the regulations of the fire insurance companies was either put on slate or on a brick wall. These wires were not allowed to be put on wood or near wood. Such things were not allowed as bringing a wire through the frame work of a window. That would not be tolerated. When they come inside, they come

almost immediately to the cut-out, and even if there happened to be a ceiling three feet above, the fire insurance companies insisted on large sheets of asbestos being fixed against that. Our converters, inside of iron boxes, are fixed to the wall; and on the way to the converter there was the usual switch for cutting the whole installation out. Of course, this switch was very seldom used by the householder; it was more for the convenience of the central station people than for the householder.

Now, before going further I would say something of a class of wire that was used. I think the reason that English work has taken the particular line it has, is probably due to the fact mentioned by Mr. Lockwood, that England has done all the submarine cable work so far. We were accustomed to expensive wire for cable work, and consequently we did not kick when we had to pay £250 a mile for such a cable as 19 15's, which I dare say you would think a good deal here. The class of conductor we used was made of 19 No. 15's tinned. This was then wrapped around with three wrappings of fine rubber such as you use in making joints. Then on the top of that, comes what is called a white rubber; that is wrapped on two or three times spirally; outside of that, there is another of what is called black rubber. These two outside rubbers have vulcanized material mixed with them. When that cable is made to the thickness of insulation generally used, and used now—one-eighth of an inch of rubber—the cable is then put in the tank and vulcanized. Now, there is one point that cannot be too strongly insisted on, namely:—that it is no use having an expensive cable like that if you are not going to protect it thoroughly. India rubber will stand fairly well under water. It will stand fairly well in moist weather, but will not stand in dry air and it will not stand in alternations of wet and dry. If you expose the rubber to the air it will in time perish. It is also liable, if it rests on anything sharp or sharply rounded, to get very thin at that point. It does to some extent flow away from the point and the insulation gets very thin. The way we went to work was this: On the outside of that cable is a fine waterproof tape, which is vulcanized upon it and absolutely forms part of it. How much further we go depends on circumstances; but a general rule was to take a compounded tape, that is, a strong linen tape twilled and dipped in some compound of ozokerite, and this was wrapped around in one or two coatings. Outside of that we carefully put on a strong braid of yarn, and the whole was then thoroughly saturated with the compound. You have then done about all you can do, and I may say that in London I believe there are three or four miles of cable of that class, which has now been lying in iron pipes carrying a tension of 2,500 volts without any accidents. The cables are simply drawn into the iron pipes and lie side by side. I know that the Silvertown people four or five years ago laid down such cables as that for arc lighting throughout their works. The grounds at their works are fairly saturated with various mixtures, yet it has given them no trouble at all since. I cannot help thinking that if your cable is properly protected it will not give trouble. That cable, of course, before it leaves the manufacturer is carefully tested. I have spent months in testing telephone and electric light cables of that character. This class of cable manufactured by the Silvertown company would test from 2,000 to 8,000 megohms to the mile at a temperature of 75 degrees. If you put the testing current on a cable like that it flows into the cable with a great rush, and then the rush diminishes and you gradually see the spot of light coming back. One should always watch that spot of light for 10 minutes. Sometimes it will give a little kick, and that will denote that something is not quite right. But the Silvertown people have told me, and I know it to be a fact, that in manufacturing submarine cables they have run out as many as 70 miles of cable without locating any fault that they were obliged to cut out.

As to installation work, inside wiring, that is also done with first-class rubber covering thoroughly vulcanized. It usually depends a good deal on the fire insurance inspector. One man will pass one thing and another man will not pass it. You have got to know your man. Mr. Musgrave Heaphy first succeeded in imposing his rules more or less generally, and things now I believe are fairly up to his standard. His standard means that no wires are to be within an inch of each other in wood casing; that wood casing is used everywhere; that there is no exposed wire; that there are cut-outs to every two or three lamps; that the cut-outs have all slate or porcelain bases; that all switches have porcelain solid bases, and that no screws communicating with the current are allowed to come in contact with wood work at all.

No doubt we have sacrificed rapidity of progress to some extent, and we have had a lot of trouble, still there has been immunity from accidents which is very gratifying and the work will stand. There is no doubt that the people when they put electric lights in their houses have an idea that it is going in just the same as gas fittings, but a good deal of the electric work put in in past years I do not think would last as long as fair average plumbing. I am very much obliged to you for listening so appreciatively.

The Chairman—I would like to ask Mr. Addenbrooke his opinion on the proposition which we have heard considerable of within a few weeks, namely:—that while there is no particular difficulty in insulating a direct current of 3,000 or 4,000 volts, it is absolutely and entirely impossible by any known means of insulation to insulate an alternating current of a thousand volts. What is your experience as to that?

Mr. Addenbrooke—I think my experience was as fully and carefully stated—it is not a subject on which one likes to make a more or less random shot—but my experience was pretty fully stated in the *Electrical Review* (London), three or four years ago. I do not think there is anything whatever to show that the alternating current will break down insulation quicker than a continuous current. I know a great many statements are made on the subject, but I do not know of any experiments which can be produced to verify them. I do not know of any one in England or America who has made a careful series of experiments on that point. We all know that the alternating current will not produce anything like the arc that the continuous current will. A continuous current of a thousand volts will produce an arc—I would not like to say how much longer than an alternating current will produce. We know that a cable does not receive the full charge of electricity, while you can see the movement of the galvanometer an hour after the cable has had the current on, but of course the great rush occurs immediately. Still it takes a very appreciable time, and in the case of an alternating current, we will say alternating 200 times a second, it is quite conceivable—I do not say that it is a fact, but it is worth putting forward—that the insulating substance around that cable has not time to get sufficiently polarized to allow the discharge to pass through quickly before the current has turned in the other direction, and has depolarized it. I do not say that that is a correct view. It is a thing that requires to be gone through very carefully. From all the observations I have seen and what I have heard on the question of insulation, I think that an alternating current will not go through more quickly than a continuous current.

The Chairman—The English telegraphic engineers have always taken the ground that a submarine cable was less injured by an alternating than by a continuous current. They have used the double current system on defective cables, in preference to the single current system, which will tend to prove, I suppose, that they apprehended more trouble from the breaking down of the insulation by the continuous current than by the alternating.

Mr. Lockwood—The hour is late, so I shall make my remarks in reply to questions very brief. Mr. Ralph W. Pope mentioned the subject of pneumatic tubes, and that very little or nothing had been said in my paper upon that subject. I think perhaps I may be excused for the reason that there was very little or nothing to say. It is true that pneumatic tubes are much more extensively used by the British telegraph authorities than they are used here, because it is apparently one of the maxims of the British telegraph authorities that it takes a longer time to deliver a message than it does to send it. I am sure that the same view is borne out by the experience of every one of us who has ever had occasion to send or receive a despatch, and so instead of filling up the large cities such as London, Liverpool, Manchester and Birmingham with telegraph sub-offices, at about every hotel and every 10 blocks, they have organized a system of pneumatic tubes which is very like that of the Western Union in New York, but on a much larger scale, and as a general thing, they send their messages in packages in a pneumatic tube from one point to another.

In respect to the inquiry made by Mr. Garratt concerning the relative method of inside construction in electric lighting, and how they get along there with the inspectors, I think that has been sufficiently answered by Mr. Addenbrooke.

Mr. Martin thought something should have been said regarding the electric motor railway service. There are not anything like as many street car roads as there are on this side. But it is only within the last 25 years that street car railways were introduced into England by Citizen George Francis Train, and they called them tram roads, not from any connection with Mr. Train, but because there were tram roads in collieries, before Mr. Train was heard of. During the 24 years I was absent from England, I found there had been a great advance in street railroad business. But they are not a fast nation. In England they would rather do a thing well once than do it fast a dozen times. So they found the horse car a pretty good thing to stick to, and they have made more of it than we have done, because they make all the cars double deckers; not only that, but they use steam dummies to a very large extent, and between Birmingham and Soho and other districts I find they use the traction cables, and it gives good service. One of the electric roads I had the pleasure of traveling on was about a couple of miles long, and situated on Brighton Beach. It is a very poor kind of a thing to look at, but it is in a safe location—on the sands of the sea-shore, and it does not trouble a single telephone wire. The current passes through the two rails. The Port Rush road is still there, and as I understand is doing good service. I had not time to see it. After all is said and done the main reason that electric motor roads, operated as we operate them with a single wire overhead are not more common, is the reason mentioned by Mr. Addenbrooke, reinforced by the very potent hand of the central government which knows

that the operation of such an electric railway in such a way would be a great deal of a nuisance to its own telegraph wires, and would mean death and destruction to all telephone wires in the kingdom, which will possibly be all government property some day. I asked Mr. Preece about that and he reminded me that he had presented to the Institute of Electricians over there a paper showing very clearly the evil results to all electric systems operating sensitive instruments, of railway or electric light systems using the earth for a return. I also enquired of a gentleman well informed in electrical matters, why the electric railways were not more used with the overhead wire, and he said because they would not be allowed. I thought that was a very good, solid reason, and when I told them how they were being sown broadcast through the land here, and how, when harmless telephone companies remonstrated, they were universally met with the cry that the telephone companies wanted the earth, he said "That is very true; they want the earth here also, but they want it to work on like any other peaceable mortals and they do not propose to allow that a tiger has the same right to walk the earth that a man has." And that seems to me the principal reason why the electric railway has not made more progress than it has in England.

I do not know that I have anything more to add except to express my gratification at the very lucid demonstration made by Mr. Addenbrooke. He said one or two things that I should like to have said myself, but I am going to stay in the country and he is not. I thank you, gentlemen, for your very kind attention.

The Chairman—In closing this very interesting discussion, I will take the liberty of expressing the thanks of the meeting to Mr. Addenbrooke for the information he has given us, and will announce that the next paper before the Institute will be read on the evening of October 29, by our fellow member, George B. Prescott, Jr. His subject is "Some Methods of Regulating Accumulators in Electric Lighting."

THE WESTINGHOUSE EDISON LITIGATION.

DECISION IN THE SUIT OF THE CONSOLIDATED ELECTRIC LIGHT CO. *vs.* THE MCKEESPORT LIGHT CO. FOR INFRINGEMENT OF THE SAWYER-MAN LAMP PATENT.

FOLLOWING is the full text of the decision in this important case, written by Justice Bradley, as Circuit Justice, Western District of Pennsylvania, filed October 5, 1889.

BRADLEY, *C. J.*:—

This is a bill for the alleged infringement of a patent filed December 8, 1887; and the patent alleged to be infringed is dated May 12, 1885, and is for improvements in electric lamps; it was granted upon application of William E. Sawyer and Albon Man, of New York, to their assignees, the Electro-Dynamic Light Co., and by mesne assignments was transferred to the complainants, whose title commenced in October, 1882, before the patent was issued. The application for the patent was filed January 9, 1880, and the issuance delayed by various proceedings in the Patent Office, including an interference with an application of Thomas A. Edison, which had been filed a month earlier, to wit: December 11, 1879. Various defenses were set up in answer, such as anticipation by prior inventions, vagueness of description, want of novelty and utility, undue change of specification after filing, surreptitious claim of an invention made by Edison, etc. It is conceded that the defense of the suit is conducted by Edison Electric Light Co., a corporation of New York, which sells the lamps complained of as infringements of the patent and is interested as assignee in the patents for the electric light formerly owned by The Edison Electric Light Co. and in the question of interference between Edison and the complainant.

NATURE AND OBJECT OF THE PATENTED INVENTION.

In the specification of the patent sued on, called Sawyer and Man's patent, the invention is described as relating to that class of electric lamps employing an incandescent conductor inclosed in a transparent, hermetically sealed vessel or chamber from which oxygen is excluded and constituting an improvement upon the apparatus shown in a previous patent granted to the same parties (Sawyer and Man), June 18, 1878, and numbered 205,144. It is further stated in the specification that the invention relates more especially to the incandescing conductor, its substance, its form and its combination with the other elements composing the lamp and that the improvement consists: First, of the combination in a lamp chamber composed wholly of glass as described in the said former patent, of an incandescing conductor of carbon made from a vegetable, fibrous material, in contradistinction to a similar conductor made from mineral or gas carbon, and also in the form of such conductor combined in lighting circuit within the exhausted chamber of the lamp. The construction of the lamp is then described, reference being made to the drawings for illustration. The lamp as described and shown in the drawings is a glass cylinder with rounded top, cemented at the bottom to a glass disk or plate ground to fit closely to the cylinder and the whole bottom inclosed in a cup filled with wax or suitable cement to prevent as far as possible the access of atmospheric air. Two holes are made in the bottom of the lamp for the passage of the wires which convey the electric current into and out of the lamp. The carbon conductor within the glass cylinder is connected by its extremities to these two wires respectively, in a mode specified in another patent of Sawyer and Man, dated December 10, 1878, and numbered 210,809, so as to constitute a part of the circuit, and having a low conductivity and presenting a certain amount of resistance to the current of electricity, it becomes incandescent and highly luminous. If the carbon, in this condition, were exposed to atmospheric air, that is, to oxygen, it would be consumed by combustion; hence, another part of the combination necessary to the result consists in filling the lamp with nitrogen gas or other gas which prevents combustion, to the exclusion of atmospheric air. The mode of doing this is pointed out in the patent 205,144, before referred to. It is further stated in the specification that in the practice of the invention, thd applicants had made use of carbonized paper and also wood care bon; also, that they had used conductors of different shapes, such-as V-shape and with rectangular corners, but preferred the arch-shape as shown in the drawings. It is added that the description of the mode of making the illuminating carbon conductors described "and making the subject-matter of this improvement," was unnecessary as they could be made by any one skilled in the art by the ordinary well-known methods in practice.

The specification then states the proposed practical advantages of the arch form of the conductor to be its permitting the carbon to expand and contract, and casting less shadow; and the advantage of making the wall of the lamp wholly of glass to be its preventing oxidation, leakage, etc.; and states particularly the advantages resulting from the manufacture of the carbon from vegetable, fibrous or textile material instead of mineral or gas carbon. "Among them," it says, "may be mentioned the convenience offered for cutting and making the conductor in the desired form and size, the purity and equality of the carbon obtained, its susceptibility to tempering both as to hardness and resistance, and its toughness and durability." "We have used," it is added, "such burners in closed or hermetically sealed transparent chambers in a vacuum, in nitrogen gas and in hydrogen gas; but we have obtained the best results in a vacuum or an attenuated atmosphere of nitrogen gas, the great desideratum being to exclude oxygen or other gases capable of combining with carbon at high temperatures from the incandescing chamber, as is well understood."

CLAIMS OF THE PATENT.

The patent has four claims:—

"1. An incandescing conductor for an electric lamp of carbonized, fibrous or textile material and of an arch or horse-shoe shape, substantially as hereinbefore set forth.

"2. The combination substantially as hereinbefore set forth of an electrical circuit and an incandescing conductor of carbonized fibrous material included in and forming part of said circuit and a hermetically sealed chamber in which the conductor is inclosed.

"3. The incandescing conductor for an electric lamp formed of carbonized paper, substantially as described.

"4. An incandescing electric lamp consisting of the following elements in combination: First, an illuminating chamber made wholly of glass hermetically sealed and out of which all carbon-consuming gas has been exhausted or driven; second, an electric circuit conductor passing through the glass wall of said chamber and hermetically sealed therein as described; third, an illuminating conductor in said circuit and forming part thereof within the said chamber consisting of carbon made from a fibrous or textile material having the form of an arch or loop substantially as described, for the purposes specified."

THE QUESTION AT ISSUE STATED.

The great question in the suit is whether the patent sued on is valid so far as it involves a general claim for the use in electric lamps of incandescing carbon conductors made of fibrous or textile substances. If it is, the complainants must prevail; if it is not, the bill must be dismissed.

ANALYSIS OF CLAIMS ALLEGED TO BE INFRINGED.

The claims of the patent (excluding the third claim, which the defendants do not use and which is not involved in the case) may be summarized as follows:—(1) A conductor of carbon made of fibrous or textile material and of an arched form; (2) A conductor of carbon made of fibrous material in a hermetically sealed chamber without regard to form; (3) The combination of a conductor of carbon, made of fibrous or textile material in an arch form, and a glass chamber hermetically sealed and deprived of carbon-consuming gas.

The claim of the combination last named may be dismissed from consideration as a separate claim, because a glass chamber hermetically sealed for holding light has always been used and must necessarily be used in all incandescing carbon electric lamps. It was used by King in 1845; by Greiner and Staite in 1846; by Roberts in 1852; by Konn in 1872; by Kosloff in 1875, and by others.

Unless the patent is valid for the conductor of carbon made of fibrous or textile material in an arch form, it cannot be made valid by combining such conductor with a glass chamber hermetically sealed.

IS THE ALLEGED COMBINATION PATENTABLE?

We are equally of the opinion that the giving of an arched form to the conductor was not new and could not give to the claim any validity which it would not have as a broad claim of the conductor itself, made of carbon produced from a fibrous material. The arched or bent shape in incandescent conductors was applied in 1848 by Staite to an iridium conductor; in 1858 by Gardiner and Blossom to a platinum conductor; and in 1872 by Konn to a carbon conductor. In the last case, the conductor was enclosed (as it had to be) in a glass lamp or case filled with nitrogen or other gas incapable of supporting combustion. The carbon, it is true, is presented in a V-shaped form, but in a similar patent applied for a few weeks afterward, claiming the same apparatus for the production of heat, the patentee very properly says:—"It is evident that stems of other shapes may be used." If the U or V-shaped form had not been given to the carbon made of fibrous material for incandescent light, before Sawyer and Man adopted that form, it was merely the application by them of an old device to a new and analogous use. But the carbons used by Konn, included charcoal, as well as other carbons. He mentions graphite as preferable, but he claims the use of carbon generally.

CONTENTION OF THE DEFENDANT.

As before stated, therefore, the patent must be considered as making the broad claim to the use in electric incandescent lamps of all carbons made of fibrous or textile substances. Is the patent valid for such a broad claim? The defendants contend that it is not: *first*, because no such invention was set forth in the original application, but was introduced for the first time more than four years after it was filed, and after the same material had been used by Edison, and claimed by him in an application for a patent; *secondly*, because Edison, and not Sawyer and Man, was really the original and first inventor of an incandescent conductor made of fibrous or textile material for an electric lamp; *thirdly*, because if Edison was not the first inventor, the thing claimed as an invention was old, and neither of the parties was entitled to a patent for it.

The whole vegetable kingdom is composed of fibrous material, and all carbon or charcoal made therefrom comes within the scope of the complainant's claim. Silk is fibrous or textile, and carbon made from silk thread is, therefore, within the claim; mineral coal and carbon produced in gas retorts are not included.

FIBROUS CARBON OLD IN THE ART.

Can it possibly be said, when we look at the history of the art of electric lighting, that carbon made from fibrous or textile material was never used for that purpose until Sawyer and Man used it in 1878? We think not. We do not propose to describe in detail the various English patents of prior date, which have been adduced in evidence. The word charcoal, as well as carbon, is constantly used to define the material from which the conductors were made; and that word, in the English language, *prima facie*, refers to carbon, or coal made of wood. We cannot yield our assent to the ingenious theory of the complainant's counsel, and some of their witnesses, that the word has come to have an artificial or technical meaning in this particular, signifying gas or mineral carbon. We think that carbon made from wood or other vegetable material is generally intended. In King's patent, of 1845, he says: "The nature of the invention consists in the application of continuous metallic and carbon conductors, intensely heated by the passage of a current of electricity for the purpose of illumination." * * * "When carbon is used, it becomes necessary, on account of the affinity this substance has for oxygen at high temperature, to exclude from it air and moisture. To accomplish this in the most perfect manner, it should be enclosed in a torricellian vacuum." He does not confine himself to any particular kind of carbon. It is true he does afterwards say, "That form of carbon found in the interior of coal gas retorts, which has long been used, is well suited for this purpose;" but his claim is general for "The application of metallic and carbon conductors intensely heated, etc.," and the use of wood carbon would have infringed the patent. Greiner and Staite, in their patent of 1846, in describing how they prepared the carbon for the incandescing stems in their lamps, say: "We take a quantity of lamp black, or of charcoal reduced to powder, or of coke also reduced to powder, which has been purified, etc." "The carbon thus highly purified we next bring into a state of great dryness, and then convert it into solid prisms, or into cylinders, both solid and hollow, etc." The charcoal here referred to is clearly wood charcoal.

Roberts, in his patent of 1852, says: "Another part of my invention consists of a mode of obtaining electric light by passing a current of electricity through a thin piece of graphite, coke or charcoal, or other infusible body, being a conductor of electricity, whilst it is enclosed in a vacuum or space not containing oxygen or other matter, which can cause the combustion or decomposition of it when brought into an incandescent state by the action of the current of electricity." This certainly refers to wood charcoal. We have already alluded to Konn's patent of 1872, in which he claims carbon stems generally, arranged as specified in the patent, for giving incandescent light. We may add that, in the earliest experiments of Sir Humphrey Davy and others on the effects of the electric current in producing light in various substances, charcoal was one of the most frequent articles used for that purpose. Long prior to 1878 it was a well-known fact in science and the arts that the transmission of the electric current through a pencil of charcoal interposed in a metallic circuit would produce intense light; and that when the charcoal was guarded from contact with oxygen, in a vacuum or otherwise, it would not be consumed. This is fully verified, not only in scientific writings, but by the statements found in several of the patents referred to. The great desideratum was, to construct an apparatus, and to discover a process, which would make the light economical and convenient of use for ordinary domestic purposes.

CLAIM TO EXCLUSIVE USE OF CHARCOAL UNTENABLE.

We are clearly of opinion, therefore, that neither Sawyer and Man, nor Edison, can maintain any just claim to the exclusive use of charcoal generally, in any form, as an incandescing conductor in an electric lamp. This view of the subject is sufficient to decide the present case against the complainants. But there are other considerations which go to corroborate the conclusion to which we have come, which, however, we shall only cursorily examine.

THE ORIGINAL APPLICATION CONSIDERED.

It is very clear to us, that, in the original application for the patent sued on, the applicants had no such object in view as that of claiming all carbon made from fibrous and textile substances, as a conductor for incandescent electric lamps. Nothing on which to base any such claim is disclosed in the original application. We have carefully compared it with the amended application on which the patent was issued, and are fully satisfied that, after Edison's inventions on the subject had been published to the world, there was an entire change of base on the part of Sawyer and Man, and that the application was amended to give it an entirely different direction and purpose from what it had in its original form.

It is true that the last claim of the original was for "An illuminating arc made of carbonized fibrous or textile material." But this claim had special reference to the arched form of the conductor, rather than to the material of which it was composed; and their claim is the only expression in the application which even suggests any exclusive right to all vegetable carbon, or any invention or discovery in relation thereto. No advantage in the use of such carbon is anywhere alleged. The whole scope and purpose of the application related to the arched form of the conductor. A subsidiary purpose was to claim carbon made from paper or pasteboard. They say distinctly: "Our improvement consists in the employment of an incandescent arc of carbon, in the circuit, as the light-giving medium." "Carbon" generally, not any particular carbon. By an adroit amendment, made in 1885, they say: "Our improvement relates more especially to the incandescing conductor, *its substance*, its form and its combination with the other elements composing the lamp." The purpose of this amendment is obvious and needs no comment. After explaining the drawings, the original application goes on to say: "Our improved burner or incandescent arc consists of an arch-shaped or semi-cylindrical piece of carbon, A, mounted in its clamps or supports in the usual well-known ways. We have tried carbonized paper covered with powdered lumbago, wood carbon or charcoal, and ordinary gas carbon. We have also used such arcs or burners, of various shapes, such as pieces with their lower ends secured to their respective supports and with their upper ends united so as to form an inverted V-shaped burner. We have also used arcs of varying contours, that is with rectangular bends instead of curvilinear ones, but prefer the arch shape, as the shadow cast by such a burner is less than that produced by other forms of burners. We have used such burners in close transparent chambers in a vacuum, in nitrogen gas and in hydrogen gas, but have obtained the best results in a vacuum or attenuated atmosphere of nitrogen, the great desideratum being to exclude oxygen from the combustion chamber as is well understood. The operation of our improved apparatus will readily be understood from the foregoing description." Then come the claims, as follows:—*First*: Incandescing arcs for electric light made of carbon, substantially as hereinbefore set forth. *Second*: Incandescing arcs of carbon, in combination with the

circuit of an electric light. *Third:* The combination, substantially as hereinbefore set forth, of the circuit of an electric light and incandescing arc of carbonized paper included in the circuit and a close transparent chamber in which the arc is enclosed. *Fourth:* An incandescing arc made of carbonized fibrous or textile material.

THE ORIGINAL APPLICATION AND THE PATENT COMPARED.

This is the whole of the original application, except the formal introduction. The arc is everything. The changes are rung on the arc. The fact is that Sawyer and Man were unconscious that the arc was not new, and supposed that they could get a patent for it; but as their eyes were opened, they changed about and amended their application, and made the material of the conductor the great object, carbon made from fibrous or textile material. Compare the original with the amended application as first stated in this opinion, and this purpose most obviously appears. The carbons mentioned in the original application are merely mentioned, by the way, to show that the arched form would apply to all kinds of carbons. "We have tried carbonized paper covered with powdered plumbago, wood carbon and ordinary gas carbon." This is changed, in the amended application, to the words: "In the practice of our invention we have made use of carbonized paper, and also wood carbon." The object of this change is manifest. In other parts of the amended specification, the importance of vegetable carbon as distinguished from gas carbon is dwelt upon. Thus, they say, in a former paragraph: "Our improvement consists, first, of the combination in a lamp chamber composed wholly of glass, and described in patent No. 205,144, of an incandescing conductor of carbon made from a vegetable fibrous material, in contradistinction to a similar conductor made from mineral or gas carbon, and also in the form of such conductor so made from such vegetable carbon, and combined in the lighting circuit within the exhausted chamber of the lamp."

The fact that the whole object of the application was changed is evinced by the correspondence of the parties. In a letter from William D. Baldwin, one of the attorneys of the applicants for the patent, to his clients, the Electro-Dynamic Light Co. (who then owned the interest in the invention), dated January 8, 1880, he says: "I have this day prepared an application for patent of arch form of incandescent carbon-electric lamp made by William E. Sawyer and Albon Man as joint inventors, containing a request for the issuing of such patent to your company, etc. * * * I will not make any alteration in the claims or specification of said patent enlarging its scope beyond the intended purpose of covering the arch or angular form carbon used for incandescent electric lights." In a letter from Albon Man, one of the applicants for the patent, to a Mr. Cheever, dated December 12, 1880, he says: "I have received your two notes of 11th inst., enclosing letter from the Patent Office, advising Messrs. Baldwin, Hopkins and Peyton of substitution of Mr. Broadnax as attorney in *carbon arch matter.*" This had relation to the application in question, Baldwin, Hopkins and Peyton being the solicitors in the case, and Mr. Broadnax being substituted in their place. "Carbon arch matter" are words that could hardly be more suggestive. As before stated, Edison had filed an application for a patent in December, 1879, about a month prior to the application in question; and in September, 1880, an interference was declared between the two applications. The controversy raised on this interference related principally to carbon made from paper, which Edison claimed in his application. The case was not finally decided until the beginning of 1885. Mr. Broadnax was examined as a witness in this suit, and testified as follows:—

"After the decision of the commissioner of patents of the interference awarding priority of invention to Sawyer and Man, I resumed the prosecution of the application, insisting upon our right to the claims that had been once rejected by the Examiner, among which was one for the U-shaped or loop shaped illuminant. My attention was then called for the first time, by the Examiner, to the British patent of Konn, in which was shown an arch shaped carbon illuminant, and which, as I thought, anticipated broadly the claim for the U-shaped or arch shaped carbon illuminant, and then in the discussion of the case with the Examiner, my attention was called to the patentability of the fibrous carbon illuminant as such, on account of the properties such carbon possessed which made it available for electric lighting above all other carbons."

Being asked when this was, he said it followed soon after the decision of the Commissioner of Patents upon the question of priority, or as soon as he could, in the ordinary course, get the case before the Primary Examiner again; his best recollection was that it occurred in February, 1885. This testimony of Mr. Broadnax, which is undoubtedly to be relied upon, in connection with the letters just quoted, shows that the idea of claiming carbon made from fibrous and textile materials was an afterthought and was no part of the purpose of the original application. The amendment relating to this new and broad claim was made afterwards, in February and March, 1885.

We are of opinion that the changes made in the application in this regard were not justifiable, and that the claim in question cannot be sustained.

THE SUCCESS OF SAWYER AND MAN'S LAMP QUESTIONED.

There are other aspects of the case to which we might refer, which operate strongly against the claim of the complainants. We are not at all satisfied that Sawyer and Man ever made and reduced to practical operation any such invention as is set forth and claimed in the patent in suit. Their principal experiments were made in 1878, and perhaps in the beginning of 1879. The evidence as to what they accomplished in the construction of electric lamps is so contradictory and suspicious that we can with difficulty give credence to the conclusions sought to be drawn from it. We are not satisfied that they ever produced an electric lamp with a burner of carbon made from fibrous material or any material, which was a success. During the year referred to, 1878, and the beginning of 1879, they applied for and obtained 10 different patents (besides an English patent) on the subject of electric lamps; but not one of them contains a suggestion or a hint of any such invention as is claimed in the patent in suit, which was not applied for until 1880. They all relate to lamps with straight pencil burners, generally of carbon, but without any preference given to one kind of carbon over another. The application for the patent in suit was not made until January, 1880, nearly or quite a year after all their experiments had ceased, and after the inventions of Edison had been published to the world. One cannot read the patents before applied for by Sawyer and Man, with all their detail of apparatus and process for constructing and managing the straight stemmed conductors, without distinction of carbons—apparatus and processes, many of which would be needless in the lamp now claimed—without indulging some degree of astonishment at the pains and ingenuity gratuitously expended or wasted, if it was true, that, all the time they had in their possession a secret invention which would take the place of those complicated contrivances. The explanations made by the complainants for the delay for applying for the patent in suit fail to satisfy our minds that Sawyer and Man, or their assignees for them, have not sought to obtain a patent to which they were not legitimately entitled.

But suppose it to be true, as the supposed inventors, and some of the other witnesses testified, that they did in 1878, construct some lamps with burners of carbon made of fibrous material and of an arch shape, which continued to give light for days or weeks, or months; still, were they a successful invention?

Would any one purchase or touch them now? Did they not lack an essential ingredient which was necessary to their adoption and use. Did they go any further in principle, if they did in degree, than did other lamps which had been constructed before?

HIGH RESISTANCE THE GREAT DISCOVERY IN THE ART.

It seems to us that they were following a wrong principle, the principle of small resistance in an incandescing conductor, and a strong current of electricity; and that the great discovery in the art was that adopting high resistance in the conductor with a small illuminating surface and a corresponding diminution on the strength of the current. This was accomplished by Edison in his filamental, thread-like conductor, rendered practicable by the perfection of the vacuum in the globes of the lamp. He abandoned the old method of making the globe in separate pieces, cemented together, and adopted a globe of one entire piece of glass into which he introduced small platinum conductors, fastened by fusion of the glass around them, thus being able to procure and maintain perhaps the most perfect vacuum known in the arts. In such a vacuum the slender filaments of carbon, attenuated to the last degree of fineness may be maintained in a state of incandescence without deterioration for an indefinite time and with a small expenditure of electric force. This was really the grand discovery in the art of electric lighting, without which it could not have become a practical art for the purpose of general use in houses and cities.

THE GREAT DISCOVERY DESCRIBED.

It is unimportant to trace the various steps by which this great discovery was arrived at. It is well indicated and shown in Edison's patent applied for in April, 1879, and issued May 4th, 1880, No. 227,229; and is more fully described in that which he applied for November 4th, 1879, and issued January 27th, 1880, No. 223,898. An extract from the latter will serve to explain the principles of this invention. Edison there says: "Heretofore light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels in which the atmospheric air has been replaced by gas that did not combine chemically with carbon. The vessel holding the burner has been composed of glass cemented to a metallic base. The connection between the leading wires and the carbon has been obtained by clamping the carbon to the metal. The leading wires have always been large, so that their resistance shall be many times less than the burner and in general the attempts of previous persons have been to reduce the resistance of the carbon rod. The disadvantages of following this practice are, that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of

ideas written or spoken, as a giant mover of masses, as a lantern bearer, as a storer and carrier of power, as the most powerful and yet most delicate chemical reagent, as a heating agent under perfect control, and in many other ways the ether has been called to do man's bidding, that wondrous agent which has place in nature co-extensive with nature itself. In these allusions to electrical work I cannot forget that to theoretical science in England, and to its great leaders, we owe much of the growth and development which have led our beginning, feeble as it yet is, of an understanding of the nature of electric and magnetic phenomena. In conclusion, I join in the heartiest manner in the response to the toast in expressing for myself and the society which I represent, a most thorough appreciation of the friendly spirit and kind wishes shown. (Cheers.)

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.—RESOLUTIONS ON OVERHEAD WIRES.

Following the recent excitement in New York about electric light wires, the Executive Committee of the National Electric Light Association met in that city, October 25 and 26, and after a somewhat protracted discussion adopted the following resolution:—

Whereas, There has been considerable discussion of late regarding the possibility of successfully operating underground wires, and successfully insulating overhead wires carrying currents, both direct and alternating, of the intensity now in use for arc and incandescent lighting, and

Whereas, It is proper that an expression of opinion on this vital subject should be heard from the National Electric Light Association, the object of whose members is to supply currents of all electromotive forces for lighting, heating, welding, telegraphing, and for all the uses to which this protean power can be applied, and whose membership, extending over every state and territory of the United States, is made up of those actively engaged in distributing this power and of manufacturing the machines and supplies by which it is produced, distributed and utilized; therefore, be it

Resolved, That the following is the sense of the Executive Committee of said Association, now met for the purpose of making itself heard by the public and others in authority:—

First, That currents, both direct and alternating, of the intensity or electromotive force now in use in this and other cities of the country, are absolutely necessary for the successful and economical distribution of electricity for arc and incandescent lighting and power purposes; and that to substantially reduce the electric pressure or electromotive force of the currents now in use would so increase the cost of electric light and power as to put them out of the reach of many of their present consumers and greatly cripple the electric light and power industries in which many hundreds of millions of dollars have been invested, and which has become a public necessity.

Second, That the accidents which have recently occurred in this city from contact with the overhead wires have been due to faulty construction and defective insulation, coupled with restrictive legislation and divided responsibility which for years have prevented such comprehensive repairs and reconstruction as would have insured safety and good service;

And further, That the progress in the art of insulation has been such that overhead wires carrying direct and alternating currents of the intensity now in use can be so insulated as to be safe. The correctness of our position is shown by the fact that alternating currents of five times the intensity of those used in this city for electric lighting are operated without accident to person or property.

Third, We deprecate the effort on the part of certain electric lighting interests, who have committed themselves to the use of low tension currents, to so direct the present public discussion as to bring the high tension alternating and direct currents into disfavor, in the hope of benefiting themselves and injuring their rivals. We regard the present discussion as beneficial to the public and electric lighting industries, in that it will result in bringing more forcibly to the attention of the public authorities and the electric illuminating companies themselves the necessity of adopting proper rules and regulations insuring the use of wires of good insulation, scientific construction and distribution, and of a thorough and systematic plan of inspection and repair of overhead wires, and, generally, the adoption of such precautions as (we are confident) can and will insure safety to the public, as well as to the employés of the companies themselves.

THE BRUSH ELECTRIC CO. SELLS OUT TO THE THOMSON-HOUSTON ELECTRIC CO.

Since the last issue of this journal the Brush Electric Co. is reported to have sold its entire plant, business and patent rights to the Thomson-Houston Electric Co. There seems to be no reason to doubt the authenticity of the report.

The entrance of the Brush company into the alternating current field placed it in direct competition with other alternating systems, including that of the Thomson-Houston company, and the reported transaction, virtually consolidating two important and rival interests, does much to simplify the situation and strengthen the hands of the Thomson-Houston company.

No official statement has yet come from the companies interested.

HAROLD P. BROWN AGAIN.

In view of the wide-spread publication by Harold P. Brown in various newspapers and in a pamphlet, called "Electrical Distribution of Light, Heat and Power," of allegations that the alternating current is extremely dangerous to life, accompanied with some thirty instances of death claimed to be due to contact with alternating circuits, the Westinghouse company have caused an investigation of Brown's alleged facts to be made, the result of which fatally discredits that "electrical engineer" as to trustworthiness, if not as to good faith.

Out of thirty cases in which Brown asserts death to have been caused by alternating currents, the Westinghouse system is accused by name in 15, while in the remaining 15 no particular system is named by him. There would appear little, if any, doubt of his animus against the Westinghouse company.

The investigation of Brown's allegations has brought out the following result:—

Probably true	1
Possibly true	1
Number where there were no Westinghouse plants at the time of accident	12
Number untrue or due to other than alternating circuits	16
Whole number of Brown's allegations of death from alternating currents.	30

A few instances of the comparison of the allegations with the facts are given below:—

Allegation.—AUSTIN, TEX.—*Edmund Ramey*, porter in billiard hall, killed on roof, August 27, 1888, by touching insulated wire on Westinghouse alternating current circuit.

Fact.—This man was killed by the current from an arc light dynamo on a motor line while washing a skylight window.

Allegation.—DALLAS, TEX.—*Thomas Madigan*, plumber, killed while at work in Grand Windsor Hotel, on April 23, 1889, by shock through water-proof insulated wire carrying alternating current.

In the New York Evening *Post*, of May 11, 1889, Brown says a Westinghouse dynamo caused this accident at Dallas.

Fact.—No Westinghouse Electric Co. plant here.

Allegation.—HOBOKEN, N. J.—*Joseph O'Neill*, lineman, Electric Light Company, killed August 8, 1888, on pole having both pulsating and Westinghouse alternating current wires; character of burns, and fact that arc lamps were not running, would indicate that the latter killed him.

Fact.—O'Neill was killed at 8 P. M. by the arc light current. The alternating current wires were not all in place, and the Westinghouse Electric Co.'s dynamos were not in use until after O'Neill's death.

Allegation.—TRENTON, N. J.—Engineer Westinghouse Electric Co. killed by touching Westinghouse alternating current circuit.

Fact.—No one has ever been injured here by the Westinghouse Electric Co.'s alternating current to such an extent as to prevent his continuing on duty.

It is to be hoped that other companies supplying alternating current apparatus will take the trouble to investigate Brown's statements.

MEETING OF THE AMERICAN STREET RAILWAY ASSOCIATION.

The eighth annual meeting of the American Street Railway Association was held at Minneapolis, Minn., October 16, 1889.

The president's address contained the following:—

"The past year has been one of changes in the motive power of street railways. Rapid transit is in demand. Electricity and cable power are the systems coming into general use, with the former in the lead. The overhead electric system has thus far been demonstrated to be the most practical; but it is the hope and wish of every street railway manager that the system will be superseded, and that the motor of the future, be it electricity, gas, air, steam or some other power, must and will be a motor independent of a central plant or a wire circuit. The demand for such a motor has enlisted capital and labor of a quantity and quality that is certain to bring about the desired result within a very short period."

The executive committee, in their report, said of electricity:—

"During the last few years each succeeding year has seen electricity progress far more rapidly than any other motive power, and this has been especially so in the organization and operation of new roads."

The executive committee presented a report on electricity embracing some discussion of the relative merits of electric and cable traction, mainly favorable to the former—accompanied

with figures showing the cost of operation on several electric roads—but without names or locations or any detailed division of expenditures, and, therefore, of little value. The committee's estimates of the relative cost of construction of cable, overhead and storage battery electric roads were as follows :—

Ten mile road—15 cars.

Cost of cable construction	$700,000
Cost of power plant	125,000
Cost of cars	15,000
	$840,000
Electrical overhead wire construction .—	
Cost of road-bed	$70,000
Cost of wiring	30,000
Cost of cars	60,000
Cost of power plant	30,000
	$190,000
Storage battery :—	
Cost of road-bed	$70,000
Cost of cars	75,000
Cost of power plant	30,000
	$175,000

THE PARIS EXPOSITION—AMERICAN AWARDS.

In the official list of awards to exhibitors at the Paris Exhibition, appear the following American names :—

Grand Prize.

The American Bell Telephone Co.
Thomas A. Edison.
Elihu Thomson.
Elisha Gray.

Gold Medal.

Cobb Vulcanite Wire Co.
Heisler Electric Co.
Okonite Co.
Sprague Electric Railway and Motor Co.
Volta Graphophone Co.
Western Electric Co,

Silver Medal.

Commercial Cable Co.
Consolidated Telegraph and Electrical Subway Co.
Elektron Manufacturing Co.
Elmer A. Sperry.

Bronze Medal.

Electrical Supply Co.
Solar Carbon Co.

Honorable Mention.

Medbery Conduit System.
Munson Lighting Co. [?]
Warton. [Wharton?]

In the class of electricity there were but 12 grand prizes altogether. One-third is a fair allowance for the United States against all the rest of the world.

COLLEGE NOTES.

Cornell University—Sibley College.

The Electrical Engineering Association has been re-organized. The following officers have been elected for the ensuing term :—Wm. H. Powell, president ; W. B. Tobey, vice-president ; W. N. Smith, secretary,

Three meetings have been held. On October 14, Mr. B. W. Snow, instructor in physics presented a paper on the "Recent Researches of Hertz Concerning the Relations Between Electricity and Light." On October 21, Professor A. W. Smith gave a lecture on "The Fly-Wheel Governor for High Speed Engines." On October 28, L. B. Marks, R. G., spoke on the "Life and Efficiency of Arc-Light Carbons," giving the results of original investigation, and showing some interesting microscopic photographs of the cross-section of the various carbons tested. The results of his investigations will be published in a short time.

Recent graduates are now occupying positions as follows :—Ervin S. Ferry, Professor of Applied Sciences at Kalamazoo College ; Albert Scheible, with the Swan Incandescent Lamp Co., Cleveland, O.; J. W. Kirkland, Thomson-Houston Electric Co., Chicago ; C. L. Cornell, Western Engineering Co., Kearney, Neb.; F. N. Waterman and W. K. Archbold, Westinghouse Electric Co., Pittsburgh ; A. C. Balch is a member of the firm of Baker, Balch & Co., mechanical, electrical and civil engineers, Seattle, W. T.; F. G. Schlosser, Laclede Gas Light Co., St. Louis, Mo.; H. H. Morehouse, Tucker Electric Co., New York ; A Vickers, C. and C. Motor Co., New York ; G. L. Teeple, Western Electric Co., Chicago ; John Upp, Robinson Foster Electric R. R. and Motor Co., Boston . C. R. Van Trump, Edison Electric Light Co.; A. L. Register and Franklin Sheble, Thomson-Houston Electric Co., Lynn, Mass.; Lee Parker, superintendent of a Brush plant at the State Reformatory, Elmira, N. Y.

Harvard University.

The various courses in physics and mathematics open this fall with a far greater number of students than ever before. This is due in a measure to the interest aroused by the lectures on general physics given last year, but mostly to the presence of the men who are studying to be electrical engineers. There are quite a number of them, and Harvard's new move in this line is evidently a success.

Physics 4 (electro-dynamics) have had to seek new quarters for laboratory work on account of its unusual size, and a new laboratory has been fitted up for it on the ground floor of the Jefferson Laboratory. The instruments are placed on stone tables, supported by pillars having independent foundations; and this, together with the position of the room and the total absence of iron in its construction, make it an almost ideal place for magnetic work.

The University has kindly allowed the Electric Club to use one of the rooms in the Lawrence Scientific School building for its reading room, and the club is now fitting it up. At the last meeting, a paper on Transformers was read by G. T. Page, '92; and 16 new members were proposed. The next paper will be by Mr. G. H. Chittenden, '91 ; and Professor John Trowbridge has kindly consented to read an informal paper some time in November.

The Thomson-Houston company has presented the Jefferson Laboratory with one of its well-known stationary motors.

Storage batteries, and some of the newest forms of measuring instruments, are to be added to the equipment.

Columbia College.

The new course in electrical engineering in the School of Mines, was regularly started at the opening of the college.

The building erected specially for electrical and mechanical engineering purposes was delayed considerably by bad weather during the summer, and is not quite ready for occupancy. But fortunately temporary accommodations with ample space were found in an adjoining building, where for the present the electrical instruction is given.

The work begins very satisfactorily with 14 students, about as large a number as can be advantageously instructed at present. More than half of the students are already graduates of the School of Mines in civil and mining engineering, and the rest are graduates of other colleges. These men make most desirable students as they are already well educated. In fact the requirements for admission are such that the students are sufficiently advanced to be able to give their whole time to electrical work uninterrupted by instruction on general subjects.

The regular course for the degree of electrical engineer extends over two years, it being considered that the usual one year electrical course is not sufficiently long to teach thoroughly a subject of the magnitude and difficulty of electricity even though the entire time be given to it. There is, however, a partial course of one year for those who do not care to go so deeply into the subject for which a certificate only is given.

The course of instruction consists of lectures two hours per week on "Principles of Electricity," and three hours on "Applications of Electricity," by Mr. F. B. Crocker, and three hours per week on "Electrical Measurements," and two hours on "Mathematical Theory of Electricity," by Mr. Michael Pupin. These lectures last from 10 to 12 o'clock each day, and the time from 1 to 4 is spent in practical laboratory work, under the personal direction of the instructors. This work consists in the actual construction and testing of electrical apparatus and machines, and covers measurement of resistances, electromotive forces, currents, insulation, location of grounds and faults, tests of efficiency, constants of machines, etc.

University of Michigan.

George W. Paterson, Jr., has accepted the appointment as instructor of electrical engineering from the University of Michigan, Ann Arbor, which has just established a department of electrical engineering.

Mr. Paterson graduated at Yale in 1884, and at the Massachusetts Institute of Technology in the electrical course in 1887, and on graduation was appointed instructor of mathematics at that institution.

Massachusetts Institute of Technology.

The number of students registered is 864, divided as follows :—Fourth year, 109 ; third year, 124 ; second year, 147 ; first year, 260 ; specials, 224.

Following is a partial list of the position now filled by graduates of last May in the department of electrical engineering :—F. W. Bradley, constructing engineer, United Edison Company, New York ; J. N. Bulkley, with Wright Engineering Co., Boston ; F. L. Dame, with Westinghouse Electric Co., Pittsburgh, Pa.; J. P. B. Fiske, with Thomson-Houston Electric Co., Lynn, Mass. ; H. M. Hobart, with Thomson-Houston Electric Co., Lynn, Mass.; G. B. Lander, with Marr Construction Co., Pittsburgh, Pa. ; H. H. Hunt, with Thomson-Houston Electric Co., Lynn, Mass. ; F. A. Laws, assistant in physics, Massachusetts Institute of Technology,

Boston, Mass.; C. W. Power, with American Bell Telephone Co., Boston, Mass.; G. W. Rounds, with street railway department, Thomson-Houston Electric Co., Lynn, Mass.; C. H. Warner, with Thomson-Houston Electric Co., Lynn, Mass.; F. P. Whitney, with Thomson-Houston Electric Co., Lynn, Mass.

A course in electro-metallurgy is to be established provisionally in connection with the department of mining engineering, the fourth year students in which are to be instructed in the more essential electrical measurements, to be followed by the electro-deposition of copper, and the separation by electrolysis of gold and silver from copper, and other work of like nature.

To lessen the jar from the machinery of the dynamo room in the laboratory, a heavy brick and concrete wall, resting on railroad iron, has been built during the vacation. The wall is in the sub-basement, and supports the main shaft. A new Hill clutch has been placed on the main shaft.

Mr. James P. Monroe, secretary to the faculty, is about to leave the Institute. He will be succeeded for the present year by Mr. Harry W. Tyler, of the department of mathematics.

THE JULIEN ELECTRIC CARS ON FOURTH AVENUE, NEW YORK.

An independently propelled car has many advantages, in a city like New York, over a system dependent upon long lines of conductors, overhead or underground and a central source of supply. The storage battery seems to be the only means at present available of obtaining such a result.

The first of the standard cars of the Julien Electric Traction Co., operating on the 4th and Madison avenue lines in New York city (car No. 7) ran over 6,000 miles and carried over 80,000 passengers with such satisfactory results and at such small cost that the Julien company began the construction of 30 cars at the works of the John Stephenson Co., based on the experience gained by car No. 7; the first of these cars—No. 8—was placed on the road June 22, and on August 8, car No. 17—the last of the first group of 10—was placed in service and have since then, run continuously in regular passenger service, to the great satisfaction of the Julien company and of the officials of the 4th and Madison avenue road.

The performance of these cars are particularly creditable, when it is considered that they are sent out between horse cars, and are dependent entirely on their self-contained energy, and have never failed to return to the station by their non-power. They are placed in the hands of ordinary drivers, who seem to take pride in being promoted from a horse car driver to a position approaching an engineer. The road is in many ways unsuited to the operation of a mechanical system; the track, switches, and frogs are in many cases of an old pattern, and are very severely worn from the heavy trucking of a large city. The cars are run from the car stables, and owing to a lack of room many of the accessories of an electric system are lacking. The successful operation of these 10 cars is most encouraging, in view of the obvious need of electric traction on the surface roads of the city. The advantages of independently propelled cars in large cities is too obvious to dilate upon; the question is simply that of proving their practicability and economy. The record of car No. 7, and the subsequent performance of the 10 cars of the Julien company now in service go far to establish both points. The absolute cost of operating—say the Julien company—cannot, of course, be determined as yet with sufficient accuracy, nor until the system has been run as a whole for a much longer time. There is not, however, it is reported, the least doubt in the minds of the officials of the 4th avenue line, that the storage battery system will prove cheaper than horse traction. It is found on this road, that it requires less than 12 h. p. hours to make a round trip of 12 miles, and at the rate at which the cost of current is estimated, varying from one and one-half to two cents per horse-power hour, it will be seen that for a car day of 75 miles, the actual current required for the propelling of the car, would cost but $1.50 at the most. The other items of the cost of motive power, attendance at the station and depreciation, can be calculated, it is claimed, by allowing the positive plates of the batteries a life of one year, and the negatives two years, and allowing 10 per cent. per annum depreciation on the motors, regulators, etc., which being added together with the estimated cost of attendance, would bring the total cost of traction to, say, $4.00 per day as against $6.50 for horse traction on the same line.

The electric cars on the 4th avenue line, have a 16 foot body mounted on an independent rigid truck with a six-foot wheel base, on which are placed two 10 h. p. motors; the truck is entirely independent of the car body and may be removed at any time. The weight of the car, mounted on its truck, with motors, gearing and battery in position, is between six and seven tons. The motors are geared direct, one to each axle, and are readily accessible from the car floor through trap doors. The battery consists of 108 cells, placed in six trays of nine each, on each side of the car; these trays are pushed into the car through the outside panels, under the seats. The battery has a total capacity of about 35 electrical horse-power hours. The cars are geared for a speed of from 9 to 10 miles an hour on the level. Cars are operated from either end by a regulator worked by the driver, and no one is better able to run the car than a horse-car driver, owing to his familiarity with the brakes. Putting on and shutting off of the power is learned thoroughly in a few trips.

The regulator used on these cars is very effective, the power being varied by different groupings of the accumulators. A powerful brake is used on all cars which in case of emergency, can be supplemented by the reversal of the motors from the regulator, and the car stopped promptly when going at full speed. Five 16-c. p. incandescent lamps are used to light the car, and a warning gong is also sounded by current from the battery. The truck employed in these cars is to some extent, a departure in electrical railroad construction, being made of wood, which in addition to deadening the sound of the motors and gearing, takes up all vibration and prevents the loosening of parts which is found to be so common in cable and other mechanical cars employing iron trucks. The body is supported on rubber cushions which not only renders their riding most delightful, but prevents all strain on the car body proper in suddenly stopping or in the rounding of curves. Since these cars have been placed in service, they have never missed but one trip (caused by a broken wheel flange).

When storage batteries were first introduced upon street cars, the matter of handling and charging batteries was seen to be of much importance and some difficulty. Each car requires 216 accumulators (a double set) each measuring 6 x 6 x 7 inches, making, in a large installation, a formidable mass of material to be handled. Their battery shifting device is a characteristic and ingenious feature of the Julien company's plans. The car runs into the station between two elevators 16 feet long composed of two shelves, the lower one containing a charged set of accumulators, while the upper one is to receive the discharged set, when withdrawn from the car. When the fresh set has been put in place through the outside panels of the car, the car goes out, and the elevators are raised between two series of racks into which the discharged batteries are placed. The batteries which are in six trays on each side of the car, make automatic contact with the regulator the moment they are pushed into position, and they in the same manner make contact with the dynamo, as soon as they are placed on the charging shelves. These elevators are run by stationary electric motors, and the entire change from the time the car enters the station until it is again on the road, occupies, it is said, but three minutes. While the battery is being changed, the regulators and motors are examined. These elevating racks, with motor, etc., occupy a ground space of but 24 x 7 feet on each side of the car, or 336 square feet, which represents the stall room of 135 to 150 horses, or 6,000 square feet. This item of the saving in floor space is one of great importance in large cities, where land is at a premium, to say nothing of eliminating the risk of such fire traps as horse car stables have been hitherto.

The officials on the 4th avenue road have manifested their faith in the Julien system by placing an additional order with the Julien company for a second group of 10 cars, which are now fast approaching completion.

On the 7th of October, the 10 cars now in use were put upon a new schedule of time, under which each car is now making the remarkable record of 92 miles per day. Two additional elevator racks have recently been put up at the 85th street stables, each of a capacity to serve 15 cars, in anticipation of an early further extension of the Julien electric system on this road.

JAMES PRESCOTT JOULE.—HIS DEATH, OCTOBER 11.

James Prescott Joule died at Sale, near Manchester, on Friday night, after many years of ill-health. Very few indeed who read this announcement will realize how great a man has passed away; and yet it is admitted by those most competent to judge that his name must be classed alongside of the great original workers in science. Many who have never heard of the name of Dr. Joule have heard of the "Mechanical Equivalent of Heat," a phrase, it is to be feared, that to the majority of even intelligent people has little meaning. It is mainly on the discovery of this "mechanical equivalent" that the late Dr. Joule's title to fame rests. Joule was born at Salford, Manchester, on Christmas Eve, 1818, so that he has died at a ripe old age. He was so delicate that he could not be sent to school, and so was privately educated at home. Both his father and grandfather were brewers, and young Joule and his brother also entered the business, though James soon became so absorbed in scientific investigations that he practically left the brewery to others. Soon after entering the brewery, about the age of fifteen, he and his brother were sent by their father to the great chemist, Dalton, the propounder of the atomic theory, to learn chemistry. One can easily fancy the influence of a mind like Dalton's on a youth like Joule. He seems at once to have caught the enthusiasm for scientific research, and with rude apparatus began experiments of his own, mainly on the chemical constitution of gases and on the relations between chemical action and electricity. One of his first published papers was on a new electro-magnetic engine, which he described at the

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	12	Sprague.
Albany, N. Y.	W't'rvliet T'npike&R.R.Co.	15.5	16	Thomson-Houston.
Atlanta, Ga	Atl'nta & Edg'w'dSt.Ry.Co.	4.5	4	Thomson-Houston.
Allegheny, Pa	Obs'rvat'y Hill Pass.Ry.Co.	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co	2	3	Thomson-Houston.
Ansonia, Conn	Derby Horse Ry. Co	4	1	Thomson-Houston.
Appleton, Wis	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	20	Daft.
Asheville, N. C	Asheville Street Railway	3.5	5	Sprague.
Atlantic City, N. J	Pennsylvania R. R. Co	6.5	16	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Bangor, Me	Bangor Street Railway Co	5	4	Thomson-Houston.
Bay Ridge, Md	Bay Ridge Electric R. R	2	2	Sprague.
Binghamton, N. Y	Washington St., Asylum & Park R. R	5	4	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	14	31	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co	4	4	Sprague.
Buffalo, N. Y	Buffalo, St. Ry. Co	2.5	4	Sprague.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	1	3	Daft.
Cincinnati, O	Cinc. & Inclined Plane Ry	6	20	Sprague.
Cincinnati, O	Colerain Ave. Ry. Co	5	8	Thomson-Houston.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6	Sprague.
Cleveland, Ohio	East Cleveland Railroad Co.	12	50	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	18	10	Thomson-Houston.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenp'rt Cent. St. Ry. Co.	3.5	6	Sprague.
Danville, Va	Danville St. C. Co	2	4	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co	9	12	Van Depoele.
Decatur, Ill	Citizen's Electric St. Ry	5	4	Thomson-Houston.
Decatur, Ill	Decatur Electric St. Ry	3	1	Nat.Elec.Tract.Co.
Des Moines, Iowa	Des Moines B'd G'g Ry. Co.	10	8	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Eau Claire, Wis	Eau Claire St. Ry	5	6	Sprague.
Erie, Pa	Erie City Pass. R. R. Co	12	15	Sprague.
Fort Gratiot, Mich	Gratiot Electric Railway	2	2	Van Depoele.
Harrisburg, Pa	East Har'sb'rg Pass. Ry.Co.	7.5	10	Sprague.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	3	Sprague.
Ithaca, N. Y	Ithaca Street Railway Co	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Lafayette, Ind	Lafayette Street Ry. Co	3	9	Sprague.
Laredo, Texas	Laredo City R. R.	4	4	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angeles, Cal	Los Angeles Elec. Ry. Co.	5	4	Daft.
Louisville, Ky	Central Pass. R. R. Co	10	10	Thomson-Houston.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)	1	1	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Highland Line)	2	3	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Nahant Line)	.8	1	Thomson-Houston.
Lynn, Mass	L. & B. R. R. Myrtle St. Line	3	4	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co.	4.5	5	Daft.
Marlboro, Mass	Marlboro St. Ry. Co	3	4	Sprague.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3	6	Thomson-Houston.
Newark, N. J	Essex Co. Pass. Ry. Co	2.5	4	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
New Orleans, La			1	Daft m'tr and Gibson st'ge battery.
Newport, R. I	Newport St. Ry. Co	4.5	6	Thomson-Houston.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co	2	24	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	10	26	Thomson-Houston.
Omaha, Neb	Omaha Horse R. R	10	20	Sprague.
Omaha, Neb	Omaha &Co'ncil BluffsR.R.	4	2	Sprague.
Ottawa, Ill	Ottawa Electric St. Ry. Co.	5	8	Thomson-Houston.
Ottumwa, Ia	Ottumwa St. Ry. Co	5	4	Thomson-Houston.
Peoria, Ill	Central Ry. Co.	10	15	Thomson-Houston.
Plymouth, Mass	Plym'th & Kingston Ry.Co.	4.5	3	Thomson-Houston.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Quincy, Mass	Quincy St. Ry	5	4	Thomson-Houston.
Reading, Pa	East Reading R. R. Co	2	4	Sprague.
Revere, Mass	Revere Beach Ry. Co	1	1	Thomson-Houston.
Revere, Mass. (Ex.)	Revere St. Ry. Co	2.5	5	Thomson-Houston.
Richmond, Va	The Richmond Union Pass. Railway Co	13	41	Sprague.
Richmond, Ind	Richmond St. Ry. Co	4	6	Thomson-Houston.
Rochester, N. Y	Rochester Electric Ry. Co.	7	9	Thomson-Houston.
Salt Lake, Utah	Salt Lake City R. R. Co	6.5	20	Sprague.
Salem, Mass	Naumkeag Street Ry. Co	2	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
San Jose	San Jose & Santa Clara R. R. Co	10	6	Fischer.
Seattle, Wash. Ter	Seattle Electric Railway and Power Co	5	9	Thomson-Houston
St. Catherine's, Ont	St.Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	6	14	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	10	6	Sprague.
St. Joseph, Mo	Wyatt Park Ry. Co. (Northern Division)	4.5	12	Sprague.
St. Joseph, Mo	People's R. R. Co	10	18	Sprague.
St. Louis, Mo	Lindell Ave. R. R	5.5	12	Sprague.
Scranton, Pa	The People's Street Ry	12	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	5	10	Thomson-Houston.
Scranton, Pa	Nay Aug Cross-Town Ry	1.5	3	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Southington, Conn	Southington & Plantsville Ry. Co	2	2	Thomson-Houston.
Syracuse, N. Y	Third Ward Ry. Co	4	3	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co	2.5	8	Sprague.
Stillwater, Minn	Stillwater Electric St. Ry	5	6	Sprague.
Topeka, Kan	Topeka Rapid Transit Co	17	30	Thomson-Houston.
Troy, N. Y	Troy & Lansingburg Street R. R	5	12	Sprague.

Electric Street Railways in America now in operation.—*Continued.*

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Washington, D. C	Eckington & Soldiers'Home Electric Railway Co	3	10	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	5	Thomson-Houston.
Wichita, Kan	Riverside & Sub'ban Ry.Co.	9	6	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	8	8	Sprague.
Wilmington, Del	Wilmington City Ry. Co	8	8	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	2	2	Van Depoele.

Total—Roads 102
" Miles 552
" Motor Cars 839

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Adrian, Mich	Adrian City Belt Line Elec. Ry. Co	3	4	Rae.
Albany, N. Y	Albany City Ry. Co	14	32	Thomson-Houston.
Atlanta, Ga	Fulton Co. St. Ry. Co	9	8	Thomson-Houston.
Attleboro, Mass	No. Attleboro & Wrentham St. Ry. Co	8	5	Thomson-Houston.
Americus, Ga	Americus St. Ry. Co	5.5	4	Thomson-Houston.
Auburn, N. Y	Auburn Electric Ry. Co	3	3	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets	230	300	Thomson-Houston.
Canton, O	Electric R. R	6	9	Sprague.
Cincinnati, O	Cincinnati St. Ry. Co	2.7	8	Thomson-Houston.
Chattanooga, Tenn	Chattan'ga Elec. St. Ry.Co.		2	Thomson-Houston.
Cleveland, O	B'way & Newb'ugh St. Ry.	10	16	Sprague.
Cleveland, O	East Cleveland St. R. R., Prospect St Line	5	46	Sprague.
Dallas, Texas	West Dallas St. R. R	3	2	Sprague.
Dayton, O	Soldier's Home R. R	5	10	Sprague.
Detroit, Mich	E.Detr't& Grosse Pointe Ry	8		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit City Railway, Mack Street line	2		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit, Rouge River & Dearborn R. R	1	1	Sprague.
Denver, Col	Univ'y Park Ry. & Elec. Co.	4	3	Sprague.
Denver, Col	So. Denver Cable Co	2	2	Sprague.
Dubuque, Ia	Key City Electric Ry	2	2	Sprague.
Elkhardt, Ind	Citizens Street Railway	7		Nat.Elec.Tract.Co.
Fort Worth, Texas	Fort Worth City Ry. Co	10		Nat.Elec.Tract.Co.
Fort Worth, Texas	FortWorth L'd & St. Ry.Co.	15		Nat.Elec.Tract.Co.
Huntington, W. Va		3.5	2	Short.
Joliet, Ill	Joliet St. Ry	3	2	Thomson-Houston.
Kansas City	No. East St. Ry. Co	7	10	Thomson-Houston.
Kansas City, Mo	Vine St. Ry	3	6	Thomson-Houston.
Kansas City, Mo	Metropolitan St. Ry. Co	4.5	4	Thomson-Houston.
Kearney, Neb	Kearney St. Ry. Co	8	2	Thomson-Houston.
Long Island City, N. Y.	Long Island City & Newton Electric R. R	3	2	Sprague.
Lynn, Mass	Belt Line Ry. Co	4.5	4	Thomson-Houston.
Moline, Ill	Moline St. R. R	3	2	Sprague.
Macon, Ga	Macon City & Sub'n Ry.Co.	4	4	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Milwaukee, Wis	West Side R. R	13	12	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Minneapolis, Minn	Minneapolis St. Ry. Co	8	10	Thomson-Houston.
Muskegon, Mich		4.5	5	Short.
Nashville, Tenn	So. Nashville St. R. R. Co.	6	15	Sprague.
Nashville, Tenn	Nashville & Edgefield R. R.	6	15	Sprague.
Nashville, Tenn	City Elect. St. Ry	3.5	6	Thomson-Houston.
Nashville, Tenn	Nashville St. R. R	5	8	Sprague.
Newburyport, Mass	Newburyport & Amesbury Horse Ry. Co	6	2	Thomson-Houston.
Newton, Mass	Newton St. Ry. Co	8	10	Thomson-Houston.
New York, N. Y	North & East River Ry. Co.	3	20	Bentley-Knight.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Ontario, Cal	Ontario & San Antonic Heights Ry. Co	8	4	Daft.
Passaic, N. J	Passaic St. Ry	3	3	Thomson-Houston
Piqua, O	Piqua Electric R. R	3.5	4	Sprague.
Pittsburgh, Pa	Federal Street & Pleasant Valley R. R	8½	31	Sprague.
Pittsburgh, Pa	Pittsburgh Suburban Rapid Transit Co		3	Daft.
Pittsburgh, Pa	Squirrel Hill R. R	3½	5	Sprague.
Pittsburgh, Pa	Second Ave. Pass. Ry. Co	10	10	Thomson-Houston.
Plattsmouth, Neb	Plattsmouth Electric R. R	2	2	Sprague.
Port Chester, N. Y	P. C. & Rye B'ch St.Ry.Co.	3	5	Daft.
Portland, Oregon	Metropolitan R. R	3	7	Sprague.
Portland, Ore	Willamette Bridge Co	1.5	5	Sprague.
Portland, Ore	Nultomah R. R	5	10	Sprague.
Red Bank, N. J	Red Bank & Seabright Ry	5	3	Sprague.
St. Louis, Mo	St. Louis Bridge Co	2	4	Thomson-Houston.
St. Louis, Mo		3	13	Short.
St. Louis, Mo	Union Depot Ry	10	30	Thomson-Houston.
St. Paul, Minn	St. Paul City Ry	51	20	Thomson-Houston.
St. Paul, Minn	St. Paul & Minneapolis Ry.	20	20	Thomson-Houston.
Salem, Mass	Naumkeag St. Ry	3	6	Thomson Houston.
Sarat'ga Springs, N.Y.	Saratoga Electric Ry. Co	2	4	Thomson-Houston.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Scranton, Pa	Hillside Coal Co	1	1	Thomson-Houston.
Sioux City, Dak	Electric R. R	6	10	Sprague.
Sherman, Tex	College Park Elec. Belt Line	4	5	Sprague.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Sprague.
Spokane Falls, W. T.	Ross Park St. Ry. Co	7.50	6	Thomson-Houston.
Springfield, Mo				Fisher.
Sterling, Ill	Union Electric R. R	6	7	Sprague.
Sunbury, Pa	Sunbury& N'th'land Ry.Co.	3½	3	Daft.
Tacoma, Wash. Ter	Pacific Ave. St. R. R	6	8	Sprague.
Tacoma, Wash. Ter	Tacoma Ave. St. Ry. Co	2	8	Sprague.
Toledo, O	Toledo Electric Ry. Co	2	2	Thomson-Houston.
Toronto, Ont	Metropolitan St. Ry	3	2	Thomson-Houston.
Vancouver Island	Victoria Electric St. Ry.Co.	4	4	Thomson-Houston.
Washington, D. C	Georget'wn, Tenalleytown St. Ry. Co	6	3	Thomson-Houston.
Wilkesbarre, Pa	Wilkesb're & W. Side R. R.	4	3	Sprague.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.
West Bay City, Mich.	WestBay City Elec. Ry. Co.	5	8	Sprague.
Youngstown, O	Electric R. R	5	6	Sprague.

Total—Roads 85

signal system, must now be added the fibrous carbon lamp case, particulars of which may be found elsewhere.

The decision of Justice McKennan in the Edison-Westinghouse suit on the three-wire patent, has not yet been filed.

The case of Brush *vs.* Condit, involving the validity of the Brush patent for clutch-feed for arc lamps, in which the Circuit Court dismissed the bill, was heard on appeal a few days since in the Supreme Court, and a decision may be expected by the end of the year. The result, whatever it may be, can now have little or no commercial importance.

The argument in the suit of the Brush against the Fort Wayne Jenny company, on the double-carbon lamp patent, has been heard before Judge Gresham, and the case is awaiting decision.

Evidence is now being taken in two very important suits, one of the Consolidated against the Edison company alleging infringement of the Sawyer-Man patent of 1878, for working incandescent lamps in multiple series, and the other of the Edison against the United States company on Edison's patent for a carbon filament of high resistance. Both these are cases of long standing, but every effort is being made by the respective parties to get them ready for hearing as soon as practicable.

We learn that a number of suits of great importance in reference to electric railroad apparatus and methods, are likely to be instituted as soon as the necessary preparations can be completed.

INVENTORS' RECORD.

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS

From September 17 to October 15, 1889 (inclusive).

Alarms and Signals:—*Electric Polarized Annunciator*, C. E. Scribner, 411,133. *Signaling Apparatus*, W. R. Cole, 411,120. *Electrical High and Low Water Alarm*, D. H. Streeper, 411,230, *Municipal Signal Apparatus*, J. C. Wilson, 411,407, September 17. *Hotel Electrical Annunciator-Circuit*, C. G. Armstrong, 411,772. *Bell Striking Apparatus*, T. F. Gaynor, 411,804. *Booth for Signaling Purposes*, same, 411,805. *Thermostat*, J. L. Nix, 412,115, October 1. *Circuit-Closer for Signaling Apparatus*, G. D. Burton, 412,460. *Electric Signal Controller*, G. S. Neu, 412,530. *Electrical Door-Alarm*, D. H. Streeper, 412,563, October 8. *Push-Button*, G. E. Ely, 412,845, October 15.

Clocks:—*Electric Clock System*, C. H. Carter, 411,138. *Gong-Striking Mechanism for Synchronized Clocks*, C. H. Pond, 411,168, September 17.

Conductors, Insulators and Conduits:—*Pole for Supporting Electric Conductors*, S. H. Short, 411,204, September 17. *Conduit for Electrical Wires*, C. C. Dashiell, 411,427. *Underground Conduit for Electric Wires*, G. A. Wheeler, 411,539. *Underground Conduit*, D. M. Hyland, 411,595. *Electric Insulator*, L. McCarthy, 411,749, September 24. *Wire Holder and Insulator*, J. R. Fletcher, 411,801. *Electric Subway*, I. La R. Johnson, 412,095, October 1. *Electric Conduit*, J. P. Cushing, 412,476, October 8. *Coupling-Box for Electrical Conduits*, S. P. Denison, 413,133. *Method of Making Lateral Connections in Underground Cables*, same, 418,134. *Insulator*, L. McCarthy, 418,146, October 15.

Distribution:—*System of Electrical Distribution*, R. Kennedy, re issue, 11,031, September 24. *System of Electrical Distribution for Street Lighting*. O. B. Shallenberger, 411,970. *Coupling Alternate Current Generators*. J. and E. Hopkinson, 412,185. *Method of Synchronizing Alternate Current Generators*, same, 412,186, October 1. *System of Distribution by Alternating Electric Currents*, O. B. Shallenberger, 412,932, October 15.

Dynamos and Motors:—*Combined Electric Motor and Blower*, C. J. Hirlimann, 411,030. *Electromotor*, M. A. Kissell, 411,150, September 17. *Regulator for Shunt-Wound Dynamos or other Electrical Apparatus*, L. S. Harris, 411,551. *System for Synchronizing Electric Motors*, R. H. Read, 411,611 and 411,612. *Armature*, C. F. Winkler, 411,629, September 24. *Governor for Electro-Dynamic Machines*, G. F. Card, 411,782 and 411,783. *Electric Motor*, C. C. Peck, 411,833. *Automatic Synchronizing Commutator*, R. S. Taylor and M. M. M. Slattery, 411,840. *Electric Motor*, P. Diehl, 411,982 and 411,983; H. Groswith, 412,177, October 1. *Dynamo-Electric Machine*. C. F. Winkler, 412,349. *Commutator*, same, 412,350. *Dynamo-Electric Machine*, same, 412,351 and 412,352. *Dynamo-Electric Machine or Motor*, same, 412,353. *Governor for Electric Generators*, P. J. Tracy, 412,567. *Regulator for Dynamo-Electric Machines*, W. H. Elkins, 412,700, October 8. *Dynamo-Electric Machine*, J. A. Kingdon, 412,854. *Governor or Regulator for Electric Motors*, R. Macrae, 412,928. *Discharge Device for Dynamos*, O. B. Shallenberger, 412,933. *Alternating Current Machine*, C. Zipernowsky, 413,008. *Electric Motor*, F. J. Patten, 418,085. *Dynamo-Electric Machine*, G. Pfannkuche, 413,148, October 15.

Galvanic Batteries:—*Galvanic Battery*, W. C. Thompson, 411,400, September 17. *Connector for Batteries*, W. F. Smith, 412,346. *Connecting Device for Electric Batteries*, same, 412,347, October 8.

Ignition:—*Electric Firing Mechanism for Breech-Loading Guns*, T. Nordenfelt, 411,831, October 1. *Electric Igniting Device for Lamps*, M. Carranza, 412,464, October 8.

Lamps and Appurtenances:—*Manufacture of Carbon Filaments*, T. A. Edison, 411,016. *Carbonizing Flask*, same, 411,017. *Manufacture of Incandescent Electric Lamps*, same, 411,018, and 411,019. *Manufacture of Carbon Filaments*, same, 411,020. *Arc Lamp*, F. R. Boardman, 411,088. *Lamp Shade Holder*, C. G. Perkins, 411,107. *Electric Arc-Lamp*, F. E. Kinsman, 411,287. *Holder for Electric Light Shades*, H. H. Sawyer, 411,396, September 17. *Safety Switch for Incandescent Lights and other Electrically Controlled Devices*, O. S. Bussmann, 411,423. *Globe Frame*, D. Hyman, 411,443. *Globe Frame for Electric Arc-Lights*, J. W. Jones, 411,448. *Incandescent Electric Light Fixture*, P. H. Klein, Jr., 411,452. *Manufacture of Carbons, for Incandescent Electric Lamps* J. S. Sellon, 411,474. *Arc-Lamp*, F. P. Cox, 411,713, September 24. *Carbon Clamp for Arc Lights*, A. P. Seymour, 411,936. *Globe and Reflector for Incandescent Lamps*, T. G. Hawkes, 412,089. *Arc Light*, F. von Hefner-Alteneck and C. Hoffman, 412,141, October 1. *Ceiling Block for Incandescent Lights*, S. Bergmann, 412,361. *Fitting and Hoisting Gear for Electric Lamps*, W. B. Sayers and W. H. Sturge, 412,713, October 8. *Incandescent Lamp Socket*, O. P. Loomis, 412,962. *Globe Protector for Arc Lamps*, G. C. Asmus, 413,011, October 15.

Measurement:—*Electric Meter*, H. W. Kolle, 411,042, September 17. *Galvanometer*, W. Thomson, 412,140, October 1. *Electric Meter*, W. H. Douglas, 413,088, October 15.

Medical and Surgical:—*Electrode for Medical Batteries*, H. B. Cox, 412,165. *Electro-Therapeutic Appliance*, J. S. Mellon, 412,196, October 1.

Metallurgical:—*Electro-Magnetic Separator*, W. A. Anthony, 411,414, September 24. *Electro-Magnetic Separator*, R. R. Moffatt, 411,899, October 1.

Metal Working:—*Process of Electric Welding*, C. L. Coffin, 412,599, October 8.

Miscellaneous:—*Regulator and Cut-Off*, O. S. King, and H. H. Swaney, 411,041. *Instrument for Connecting Line-Wires*, W. H. Coughlin, 411,093 *Metallic Circuit*, H. F. Campbell, 411,137. *Terminal Plug Attachment for Flexible Electric Cords*, S. C. Lafferty, 411,153. *Automatic Pole-Changer*, C. A. Danals, 411,238. *Thermostatic Fuel-Controller*, E. R. Ware, 411,311. *Cut-Out*, F. G. A. Heller, 411,380, September 17. *Process of Generating Electricity by Gas-Batteries*, P. Dahl, 411,426. *Electric Attachment for Eye-Glasses*, C. C. Smith and H. W. Martin, 411,689. *Electric Water Heater*, D. W. Smith, 411,737, September 24. *Electric Valve Device*, F. Stevens, 411,908. *Station Switch-Board and Connection*, E. W. Rice, Jr., and A. L. Rohrer, 411,930 *Cut-Out*, A. P. Seymour, 411,935. *Rheostat*, M. J. Wightman, 411,947. *Temperature-Regulator*, E. W. Beebe, 412,013. *Electric Switch*, F. M. Bennett, 412,159, October 1. *Electrically Controlled Speed Governor Mechanism for Elevators*, W. P. Gibson, 412,332. *Electrically Controlled Valve-Operating Mechanism for Elevators*, W. P. Gibson, 412,333. *Electric Current Indicator*, J. J. Wood, 412,354. *Artificial Resistance for Electric Circuits*, C. B. Askew, 412,449. *Electric Motion Controller*, G. S. Neu, 412,529. *Automatic Musical Instrument*, R. W. Pain, 412,657. *Thermo-Electric Generator*, W. S. De L. Roberts, and J. S. Mollison, 412,669, October 8. *Electric Circuit-Closing Device*, W. C. Johnston, Jr., 412,758. *Electrical Switch-Board*, J. J. Wood, 412,818. *Electric Terminal*, C. McIntire, 412,889. *Electrical Metal Detector*, J. F. Kester, 412,924. *Electrically-Operated Ice-Cutting Machine*, F. E. Kinsman, 412,925. *Process of Purifying Alcohol*, C. M. Pielsticker, 412,931. *Electrical Toy*, L. Hirsch, 413,058. *Switch-Board*, J. F. McLaughlin, 413,083. *Method of Electric Refrigeration*, M. W. Dewey, 413,136, October 15.

Railways and Appliances:—*System of Electric Generation and Distribution for Railway Cars*, E. E. Ries, 411,301. *Overhead Frog for Electric Railways*, M. J. Wightman, 411,313 and 411,314, September 17. *Electric Railway*, G. B. Fraley, 411,496. *Trolley for Electric Railway Systems*, A. L. Riker, 411,613. *Railway Signal*, A. B. Fisk, 411,742, September 24. *System for Electric Conductors for Electric Cars*, C. A. Jackson, 411,989. *Trolley for Electric Railway Service*, A. Anderson, 412,155. *Trolley Attachment for Electric Railway Cars*, J. M. Anderson, 412,157, October 1. *Electric Motor for Railway Cars*, W. M. McDougall, 412,528. *Electric Railway*, L. Daft, 412,605. *Electrical Railway Conduit and Current-Plow*, J. W. Reno, 412,666, October 8. *Electric Railway Car*, F. J. Sprague, 413,151, October 15.

Secondary Batteries:—*Receptacle for Secondary Batteries*, F. W. Huestis, 411,124. *Connector for Secondary Batteries*, S. H. Barrett, 411,370, September 17. *Method of Forming Plates for Secondary Batteries*, S. C. C. Currie, 411,786. *Apparatus for Forming Secondary Battery Plates*, same, 411,787, October 1. *Method of Electrically Reducing Plates for Secondary Batteries*, same, 412,323. *Frame for Secondary Battery Plates*, W. F. Smith, 412,345. *Secondary Battery*, F. M. Lyte, 412,639, October 8. *Secondary Battery*, H. H. Carpenter, 412,727. *Electrode for Secondary Batteries*, H. Tudor, 413,112, October 15.

Telegraphs:—*Telegraph-Key*, A. E. Johnson, 411,198, September 17; H. S. Tebbs, N. C. Lane and V. Coombs, 411,770, September 24.

Telephones and Appliances:—*Mechanical Telephone*, C. M. Radford, 411,058, September 17. *Telephone Holder*, C. T. Dickson, 411,588. *Mechanical Telephone*, W. H. Eastman, 411,767, September 24. *Microphone Transmitter*, B. Abdank-Abakanowicz, 412,579. *Telephone Station Apparatus*, same, 412,580. *Mechanical Telephone*, W. Naylor, 412,653, October 8. *Microphone*, E. F. Heydler, 412,885, October 15.

EXPIRING PATENTS.

Patents relating to Electricity which becomes Public Property in November, 1889

Reported by F. B. Brock, *Patent Attorney*, *639 F. street, Washington, D. C.*

Key, A. W. Decker, 132,815; *Printing Telegraph*, E. Gray, 132,907; *Duplex Telegraph*, J. B. Stearns, 132,930, 132,931, 132,932, 132,933; *Battery Telegraph*, W. J. Wilder, 132,997; *Printing Telegraph*, T. A. Edison, 133,019; *Automatic Telegraph*, G. Little, 133,235; *Separator*, B. C. Tilghman, 133,501.

lated districts, in which the supply from a single station is limited to a comparatively small area. But it is nevertheless true that an enormous business has grown up within the past three years in supplying electric light at a profit in our smaller cities and towns as well as in districts thinly populated or more or less remote from central stations in larger municipalities ; a business which, as every one knows, has been rendered possible only by the development of the alternating system. Mr. Edison now plants himself directly in the track of progress, frantically waving the red flag of alarm, like the rear brakeman of a stalled train, and calling upon the authorities to "prohibit entirely" the use of a method of distribution which is to-day the only commercially practicable one for supplying electricity to half a million existing incandescent lamps, and thus to render wholly valueless an actual cash investment which can scarcely amount to less than $10,000,000. The only alternative which Mr. Edison has to offer, is the proposition that the distributing power of each central station should be "confined to a capacity consistent with safety,"—that is, with his notion of what constitutes safety—coupled with the suggestion that the aid of restrictive legislation should be invoked to limit the pressure, even of continuous currents, to a maximum of six or seven hundred volts.

In presenting these considerations to the public, Mr. Edison has omitted to refer to two important facts ; first, that in the alternating system which he is so swift to condemn, a 50-volt current, incapable of harming a child, is the maximum which is permitted to enter a consumer's premises ; and second, that there is not a solitary instance on record of a consumer having been killed or even injured ever so slightly by the alternating current. As a contrast to the safety of this mode of illumination we might call attention to an incomplete list of fatalities from kerosene oil, the result of 18 month's gleanings from the newspapers, which footed up the astounding number of 3,935 persons who lost their lives from kerosene accidents during that period.

But perhaps the statement of Mr. Edison which will most challenge the criticism of well informed electricians is the assertion, which he makes positively and without qualification, that "there is no known insulation which will confine the high tension currents for more than a limited period." But it is obvious that he is forced to make this assumption, otherwise his whole argument must necessarily fall to the ground. As a matter of fact, the allegation is not true, and experience will continue to show, as it has already shown, that deductions founded upon it are erroneous. With adequately insulated street mains, and with the house wiring absolutely insulated from these mains, as is the invariable practice in alternating current installations, the element of danger, so far at least as the consumers and the general public are concerned, becomes inconsiderable.

It affords us, however, some gratification to be able to agree with Mr. Edison on one point, where he says :—

> I am not altogether familiar with the details of the system of boiler inspection which prevails in New York, but I believe it is very efficient and would serve as an excellent model for the case under discussion.

The "system" referred to is simply a legal requirement that each boiler shall be inspected by a competent expert, and its maximum pressure limited to accord with its tensile strength. No such absurdity has ever been attempted, in New York or anywhere else, as to undertake to place an absolute limitation upon steam pressure. Legislative provisions requiring the insulation of each electric installation to be tested periodically by an expert (not by a politician), and the prohibition of high pressure in cases where the insulation and other safeguards are insufficient, would meet with our entire approbation.

The real purpose of the legislative limitation advocated by Mr. Edison, however plausibly disguised under the plea of promoting public safety, seems to be a purely selfish one, having for its sole aim to hamper all the competitors of Mr. Edison's low-pressure electric lighting system with restrictions which will effectually prevent them from carrying on their business at a profit. Such an attempt deserves to fail, and we believe it will fail, in spite of the strenuous efforts now being made in every direction to manufacture, by the reiteration of ingenious and plausible misrepresentations, public opinion hostile to all electric interests ; efforts which, should they unhappily prove successful, will inflict no less damage upon their short-sighted promoters than upon those whose interests they have sought to injure.

THE NEW INDUSTRIAL ERA.

Eighteen years ago, a commission was appointed in Great Britain, to investigate the question of the probable duration of the coal supply of the kingdom. Some of the results of this official inquiry, given in a paper read before the Statistical Society, suggests some startling probabilities. At the average rate of increase and consumption which has been going on for the past twenty years it is computed that the Newcastle coal district will be exhausted in 94 years, the South Wales district in 79 years, and the remainder in even less time.

Nothing in the future appears more probable than that within the lifetime of persons now living, the industrial supremacy of Great Britain will pass away with the exhaustion of her coal fields. Switzerland, Italy, and the Scandinavian peninsula are destined to become the great manufacturing districts of Europe. This extraordinary industrial revolution will be brought about by the transmission and distribution, by electrical means, of the inexhaustible and permanent water power which is now running to waste in those countries. Indeed this power is already beginning to be successfully utilized by the skill of the electrical engineer. More than a year ago we visited in Switzerland, a woolen manufactory of 36,000 spindles, with the usual complement of auxiliary machinery, which was operated wholly by electric power conveyed from a distant stream, deriving its never-failing supply of water from the melting of Alpine snows. To an electrician, the sight was an inspiring one and full of significance. In the new era which is advancing with such rapid strides, the Swiss Republic may not improbably become the foremost industrial nation of Europe. Nothing is more certain than that the next quarter century will witness amazing changes in the commercial relations of the nations of the earth in consequence of the development of the conception of the electrical distribution of energy.

The departure of Mr. James D. Reid, to assume the duties of United States Consul at Dumfermline, Scotland, at the end of his forty-five years in the telegraph service of this country, occasions regret in a wide circle of associates and friends at the loss of his genial and kindly presence, together with congratulations upon his appointment to a post in the immediate vicinity of his birth-place and the home of his early youth. Beginning his career at the very birth of the telegraph, and in intimate association with Professor Morse, Mr. Reid was one of the leaders in the new enterprise, and has been an active participator in, and witness of, the steps that have brought it to its present prominence as an art and industry. His part therein is too well known to require mention. It is safe to say that no telegraph manager or superintendent, coming, as his calling requires, into close relations with everybody, high or low, in the service, has won more personal esteem and affection than have fallen to the lot of Mr. Reid; esteem for his probity and faithfulness, affection for his kindly and sympathetic character. Hundreds of employés and associates will remember him gratefully as one in whose eyes they stood for much more than mere moving parts in a huge machine, for he made them men and brothers.

Mr. Reid was greeted during the week preceding his sailing for Scotland, November 27, by a host of friends and associates in a series of receptions and banquets, among the most noteworthy of which was the dinner at Delmonico's, November 22, given in his honor by nearly a hundred gentlemen, comprising the president, executive officers and many other officials of the Western Union Telegraph Co., the president and vice-president of the Postal Telegraph Co., and several score of the guest's associates and personal friends. Dr. Green presided with his accustomed suavity; the speeches, so many and so good that it would be invidious to particularize, were interspersed with Scotch airs and pibrochs by the pipers in the balcony; and at the end everyone went home feeling it good to have known such a man as Mr. Reid.

The sharp advance in the price of copper during November gives timely emphasis to the movement of the Electric Light Association for the abolition of the copper tariff. The point to be borne in mind is that the unstable condition of the copper market and the present remarkable advance in price are *sequelæ* of the gigantic French corner and its collapse some months ago. The immediate cause of the advance seems to be the locking up of a considerable portion of the enormous surplus stock, left by the exploded French syndicate in the hands of bankers in France and the United States, through legal proceedings instituted by American copper mine owners. The low price reached some months after the break-up of the French speculation stimulated consumption, and it now appears from market reports that the enormous accumulation of over 150,000 tons has been brought down to 100,000 tons. The present price, about 50 per cent. above the lowest point of the year, if maintained for any length of time will certainly restrict consumption again. It should not be overlooked by consumers of copper that our customs duty was an indispensable ally of M. Secretan and his coadjutors in their temporarily successful scheme to squeeze consumers of copper the world over.

In this connection we call attention to Mr. David A. Wells's account of the course of production and price of copper for a series of years, reprinted elsewhere in our present issue from his new work on "Recent Economic Changes, Etc.;" a book whose careful perusal will well repay every one interested in economic problems and their influence upon the general welfare of mankind.

The decision, November 28, on appeal, by the Canadian Patent Office, reversing the judgment of Deputy-Commissioner Pope, who nearly a year ago declared the Edison incandescent lamp patent invalid in Canada, restores the patent to good standing on its merits. This success of the Edison interests is important, not only in the province of Canada, but also in its bearing upon the validity of the corresponding United States patent. Under the doctrine of the now famous Bate case, that patent was likely if not certain to be found invalid because of the annulment of the Canadian patent. The final judgment in Canada now clears away the cloud arising from the former decision, and leaves the United States patent to be contested on its merits rather than upon a legal technicality, a result upon which not only the Edison companies but all inventors and others interested in patent property should be congratulated.

Few persons who have had no occasion to look into the matter have any adequate conception of the importance and extent of the telegraphic service in this country. The last report of the Western Union Telegraph Co. shows that it controls one-fourth of the total telegraphic traffic of the world, and one-third the total mileage. The increase in the 10 years, 1879–'89, has been, in mileage of lines, 115.4 per cent.; in mileage of wire 206 per cent.; in number of offices 116.4 per cent.; and in traffic 115.8 per cent. The growth for the last two years would make a pretty respectable telegraphic system of itself, viz.:—21,940 miles of line, 123,056 miles of wire, and 2,812 offices.

The superstition of our school boy days, which affirmed that although a snake might be killed at any hour of the day, his tail would nevertheless continue to "wiggle" until sunset, has been fairly thrown in the shade by an enterprising reporter of an evening contemporary, who in a graphically written account of the overthrow of a horse who unfortunately came in contact with an electric wire, stated that even after the wire had been cut, it "blazed and spluttered in the gutter for half an hour." This remarkable tale appears even to have wriggled itself across the Atlantic, but we regret to say that some of our cold-blooded contemporaries on the other side, characterize it as "stuff" and "nonsense." We shall hear these epithets hurled at some of the contributors of the *North American Review*, the next thing we know.

We observe with solicitude that our hitherto esteemed contemporary, *Modern Light and Heat*, has of late manifested a tendency to emit an abnormal amount of heat, accompanied by a corresponding diminution of light. The technical knowledge of our contemporary ought to teach it that hot journals are, as a rule, neither popular with the public nor profitable to their proprietors.

The Winter Convention and Annual Meeting of the National Electric Light Association will be held at Kansas City, February 11, 12, 13 and 14. The Association Bulletin, December 1, received as we go to press, discloses a more than usually elaborate programme, enough to occupy four days with interest and profit to all in attendance.

ARTICLES.

MEASUREMENT OF ELECTRICAL APPARATUS.

BY HOWARD PEACOCK.

The observant reader of our electrical literature cannot fail to notice the unmethodical style in which the proportions of machines, wires, etc., are expressed by many of our best writers, while the careful student is annoyed and his time wasted by the constant necessity for translating feet and inches into the metric system and *vice versa.*

The weight of a dynamo is given in pounds, tons or kilogrammes, while its output is expressed in "units," horse-powers, electrical horse-powers, watts, kilowatts or volts and amperes separately numbered.

We have the dimensions of the bed-plate of a dynamo in feet, those of its armature and magnet cores in inches, while the area of its pole-pieces is reckoned in square centimeters; the length of its field coils is so many yards, meters or feet, while the cross-section of this wire and of the armature windings is given in a small fraction of a square inch, in mils and occasionally in square millimeters; and then the thickness of the armature laminæ is written in hundredths of an inch.

The sizes of wires are indicated by the arbitrary numbers of the makers; in thousandths or hundredths of an inch; in mils and millimeters; in diameters of "nearly three-tenths of an inch," "about five-sixteenths of an inch," "approximately one-eight inches," etc., etc., etc.

Why should this heterogeneous style of measurement be longer tolerated? Electro-technics has a clear, consistent and logical nomenclature of its own, the exclusive use of which would greatly simplify computations and the solution of all problems involving the measurement of electrical apparatus and would facilitate the writing, printing and reading of descriptions of machines, records of tests, experiments, etc.

It has been said that the meter, centimeter and millimeter with their symbols, m., cm. and mm., do not convey to English readers such definite ideas as yards, feet and inches. If this be true, it is also true that such readers can have no clear conception of the most usual electrical units, since these are based upon the metric system, an elementary knowledge of which is indispensable to their understanding of these units.

The English unit of length is said to have been based upon the length of the arm of a king who centuries since returned to the dust whence he came. This unit, the yard, was arbitrarily divided into certain portions having no natural relation to it or to each other, and this smallest portion has again been divided into mils, which are absurdly small, too small to be of much practical use. They cannot be seen by the naked eye and are, therefore, mere abstractions to the ordinary workman who frequently needs to know the relation which should subsist between units of current and the cross-section of conductors.

The square millimeter is small enough for all theoretical as well as practical purposes. Is not the idea of three amperes to the square millimeter more easily grasped than that of 520 mils to the ampere? In the first case we have a small number of amperes flowing through a small, but readily seen, unit of area, while the second requires us to conceive the passage of one ampere through a large number of invisible and impractical mils. Moreover, the meter is based upon a painstaking survey of an arc of the meridian, planned and executed by a body of competent scientific men. The decimal divisions of this unit render the computation of problems expressed in them ideally easy and the nomenclature of the metric system carries its meaning with it.

As the second is the unit of time in most electrical computations, why should not the revolutions of armatures be expressed as so many per second instead of 60 times that number? And the use of the centigrade degree in estimating the rise of temperature in dynamos, would be entitled to a place in the system of measurement which is here advocated.

It would, perhaps, be too much to expect the wire makers to reconstruct their gauges in conformity with the metric system, but that would follow as a natural consequence of the consistent use by electrical engineers, dynamo and motor builders of the clear and systematic electrical nomenclature we already possess. This would not only facilitate all our own work and study, but would give to our writing a value in the eyes of continental readers which it cannot now have, since they could scarcely be blamed if they concluded that our electrical "manners and customs" and the results attained thereby, were as slipshod, haphazard and generally untoward as our style of expressing them too often is.

FORM AND EFFICIENCY OF INCANDESCENT FILAMENTS.[1]

BY CHARLES J. REED.

If we pass an electric current through any conductor, as a cylindrical wire, its temperature tends to increase by the transformation of electrical energy into heat. If no heat is allowed to escape, the temperature will increase indefinitely, or until the conductor is melted or otherwise destroyed. If the heat is allowed to escape by radiation alone from the surface of the conductor, its temperature will increase only until the rate of loss by radiation is exactly equal to the rate of transformation. By heat we here include all radiant energy, whether of high or low degree.

As the temperature of an incandescent body increases, not only does the actual quantity of radiant energy increase, but its wave-lengths diminish. Hence, as experience has shown, after incandescence is reached, increasing the temperature in a given ratio, increases the light emitted in a much greater ratio.

The exact relation between temperature and luminosity is not known, and it is probably not very simple, if such a relation exists at all. The phenomenon of luminosity is really a physiological one and depends partly upon individual optical capacity; some persons being able to see above and some below the visible spectrum of the average human eye. The radiant energy we call light is one thing. The sensation of luminosity by which we always estimate light is an entirely different thing. A constant source of light may vary greatly in luminosity, according to the condition of the receptive mechanism and its individuality.

But even ignoring the physiological aspect of the question, the nearest approach we have to formulæ for radiation are the approximate empirical formulæ of Dulong and Petit and of Stefan; which are for total radiations of a low temperature and limited range. They cannot apply to light alone, nor even to total radiation of high degree.

It is unfortunate that there exists no instrument more reliable than the retina of the living eye for measuring the intensity of radiant luminiferous energy, and no method of reading the measurements more accurately than individual guesses. We can measure radiant thermal energy of low degree with Langley's bolometer; we can measure radiant actinic energy by the chemical action it produces; and we can measure total radiant energy in a variety of ways; but how can we isolate or measure radiant luminiferous energy? If there were a high temperature thermometer or other instrument for accurately measuring high temperature, we might attack this problem with some hope of results.

1. Read before the American Institute of Electrical Engineers, New York, November 19, 1889.

EFFICIENCY DEPENDS ON TEMPERATURE.

It is sufficient, however, for our present purpose to know what the eye is able to tell us, namely, that increasing the temperature increases the light in a greater ratio. From this it follows that the efficiency of an incandescent filament is some direct function of its temperature above that of the surrounding space.

OTHER CONDITIONS.

Granting that the efficiency increases with increased temperature, we have now to determine whether the efficiency does or does not depend upon any other conditions. It has frequently been claimed that the efficiency depends upon the form of the filament, whether it be cylindrical, flat or square. At a meeting of this Institute of June 8, 1886, for instance, this was by general consent considered an established fact.[2] Others have asserted, but without giving any proof, that the efficiency depends upon the pressure; some claiming that low-tension series lamps and others that high-tension multiple lamps are the more efficient. Others, again, have claimed that at the same pressure and with the same shaped filament, lamps of greater candle-power have a different efficiency from lamps of smaller power.

The trouble seems to have been that we are not always careful to distinguish between efficiency and convenience or adaptability. Each individual finds that a certain form of filament or a certain method of distribution gives better satisfaction than another or is more suited to his purpose, and soon persuades himself that it is "more efficient" than any other.

LIMITATIONS IN THIS DISCUSSION.

In order to study the effects of these various conditions upon the efficiency of a filament, it will be convenient to eliminate the effects which we know will be produced by variations in temperature. We assume, therefore, in this discussion that all the filaments, and all parts of the filaments, under consideration are at the same temperature.

Let T represent this temperature and T', the temperature of the supposed vacuous space surrounding the filament. We must assume further that the material of which the filaments are constructed is perfectly homogeneous in itself and that it is uniform in all the various forms of filaments considered.

Let S denote the specific radiating power of the material at the temperature, T, and S', its specific resistance at the same temperature.

COMPARISONS.

Any variation in S or S' might affect the efficiency and for this very reason experimental proof is very difficult to obtain. Comparisons of filaments made by different processes are entirely worthless in determining the effect of form or length of a filament on its efficiency.

It is a difficult matter to produce by the same process two carbons of different sizes and shapes that shall have the same specific radiating power and specific resistance at the same temperature. And to produce them by different processes is entirely out of the question. Any comparison, therefore, of short, series filaments with long, multiple filaments of a different manufacture is of no value whatever in settling this question.

ARGUMENT.

Let C, represent the candle-power of any filament at temperature, T.
- c, its current.
- E, the potential difference at its terminals.
- R, its resistance.
- r, its radius (considered as a cylinder).
- L, its length.
- H, the energy received per unit of time.
- H', the energy radiated per unit of time.

2. Transactions Am. Inst. E. E., vol. iv. p. 20–23.

Since the energy developed in any portion of an electric circuit is proportional to the current and pressure, we have

$$H = K\,E\,c, \qquad \ldots\ldots(1)$$

in which K is a constant depending upon the units employed.

If we neglect the small quantity of heat lost by conduction from the ends of the filament to the conducting wires, and assume that the space surrounding the filament is a perfect vacuum, then the entire energy of the current will be expended in radiation and we have

$$H = H'. \qquad \ldots\ldots(2)$$

Let K' represent a constant depending on $(T-T')$.

The rate of radiation of any surface depends only upon the elevation of its temperature above that of the surrounding space and the specific radiating power of the surface at that temperature. We have, therefore,—

$$H = H' = K'\,S \times 2\,\pi\,r\,L = K\,E\,c. \qquad \ldots\ldots(3)$$

The resistance of any conductor is proportional to its length and inversely proportional to its cross-section, and we have—

$$R = S'\,\frac{L}{\pi\,r^2}. \qquad \ldots\ldots(4)$$

From Ohm's law and (4)

$$c = \frac{E}{R} = \frac{E\,\pi\,r^2}{S'\,L} \qquad \ldots\ldots(5)$$

By eliminating successively E, c and r from (3) and (5) we get

$$\frac{K'\,S \times 2\,\pi\,r\,L}{K\,c} = \frac{c\,S'\,L}{\pi\,r^2}, \text{ or } \frac{c^2}{r^3} = \frac{2\,\pi^2\,K'\,S}{K\,S'} \qquad \ldots\ldots(6)$$

$$\frac{K'\,S \times 2\,\pi\,r\,L}{K\,E} = \frac{E\,\pi\,r^2}{S'\,L}, \text{ or } E^2\,r = \frac{2\,K'\,S\,L^2\,S'}{K} \qquad \ldots(7)$$

and

$$\frac{K\,E\,c}{K'\,S \times 2\,\pi\,L} = \sqrt{\frac{c\,S'\,L}{\pi\,E}}. \qquad \ldots\ldots(8)$$

From (6)

$$K'\,S \times 2\,\pi^2\,r^3 = K\,S'\,c^2. \text{ Hence,}$$

$$r = \sqrt[3]{\frac{K\,S'\,c^2}{2\,K'\,S\,\pi^2}} \qquad \ldots\ldots(9)$$

and

$$c = \pi\,\sqrt{\frac{2\,K'\,S\,r^3}{K\,S'}} \qquad \ldots\ldots(10)$$

showing that the square of the current is proportional to the cube of the radius or diameter of the filament for all lamps at constant temperature; and that this relation is independent of the pressure, of the length and resistance of the filament and independent of the candle-power.

From (7) we have

$$K'\,S \times 2\,L^2\,S' = K\,E^2\,r. \text{ Hence,}$$

$$L = \sqrt{\frac{K\,E^2\,r}{2\,K'\,S\,S'}}, = E\sqrt{r}\;\sqrt{\frac{K}{2\,K'\,S\,S'}} \qquad \ldots(11)$$

and

$$r = \frac{L^2}{E^2} \times \frac{2\,K'\,S\,S'}{K} \qquad \ldots\ldots(12)$$

showing that the ratio of the square of the length to the diameter depends only upon the pressure and is independent of candle-power and resistance.

From (8)

$$K^2\,E^3\,c = 4\,\pi\,K'^2\,S^2\,S'\,L^3. \text{ Hence,}$$

$$E = \frac{L}{\sqrt[3]{c}}\;\sqrt[3]{\frac{4\,\pi\,K'^2\,S^2\,S}{K^2}} \qquad \ldots\ldots(13)$$

and

$$c = \left(\frac{L}{E}\right)^3 \times \frac{4\,\pi\,K'^2\,S^2\,S'}{K^2} \qquad \ldots\ldots(14)$$

showing that the current is proportional to the cube of the ratio of the length to the pressure.

Since K', S and S' are constant, both the light and the heat radiated will be proportional to the surface and we have

$$C = K'' L \times 2 \pi r \qquad \ldots\ldots(15)$$

in which K'' is a constant depending upon the units employed and upon T.

Hence,
$$L = \frac{C}{2 \pi K'' r} \qquad \ldots\ldots(16)$$

and
$$r = \frac{C}{2 \pi K'' L} \qquad \ldots\ldots(17)$$

EFFICIENCY CONSTANT.

Combining (15) with (3)

$$\frac{K' S C}{K''} = K E c, \text{ or}$$

$$\frac{C}{K E c} = \frac{K''}{K' S} \qquad \ldots\ldots(18)$$

which shows that the candle-power is proportional to the energy, $K E c$; or that the efficiency, $\frac{C}{K E c}$, is constant and independent of the pressure, length, radius, resistance, current and candle-power of the filament. This means that the energy required to produce a given candle-power will be proportional to the candle-power and will be the same, whether it is expended in driving a large current through a short, thick filament, or a small current through a long, slender filament; provided the temperature or state of incandescence is the same and provided no heat is lost by conduction through the terminal wires.

Equation (18) shows also that the efficiency does depend upon K', K'' and S, that is, upon the temperature of the filament, the temperature of the surrounding space and the specific radiating power, and upon them only.

From (18)

$$C = E c \times \frac{K K''}{K' S} \qquad \ldots\ldots(19)$$

$$E = \frac{C}{c} \times \frac{K' S}{K K''} \qquad \ldots\ldots(20)$$

and
$$c = \frac{C}{E} \times \frac{K' S}{K K''} \qquad \ldots\ldots(21)$$

From (4)

$$r = \sqrt{\frac{S' L}{\pi R}} = \sqrt{\frac{S'}{\pi}} \times \sqrt{\frac{L}{R}} \qquad \ldots\ldots(22)$$

and
$$L = \frac{\pi r^2 R}{S'} \qquad \ldots\ldots(23)$$

From (5)

$$E = R c \qquad \ldots\ldots(24)$$

From (21) and (24)

$$c = \frac{C}{c R} \times \frac{K' S}{K'' K} = \sqrt{\frac{C}{R}} \times \sqrt{\frac{K' S}{K'' K}} \ldots(25)$$

FORM OF CROSS-SECTION.

We have thus far confined ourselves to the consideration of cylindrical filaments varying in length and diameter. It remains now to show that the efficiency is independent of the form of cross-section.

Let us suppose we have a number of lamps, all made of the same material, having the same specific resistance and radiating power, all burning at the same temperature and all giving the same amount of light. Let them be of any pressure and let the cross-section be of any form, circular, elliptical, square, triangular, etc. The filaments will all have equal radiating surfaces; since unequal surfaces of the same character at the same temperature could not radiate equal amounts of light. But equal surfaces of the same character at the same temperature must radiate equal amounts of heat of all wave lengths. Hence, the total amounts of radiant energy are equal. Since the energy received is equal to the energy radiated and the amounts of light are equal, we have

$$C = Q E c \qquad \ldots\ldots(26)$$

in which Q is a constant, and from (18) we find its value to be

$$Q = \frac{K K''}{K' S} \qquad \ldots\ldots(27)$$

EFFICIENCY INDEPENDENT OF FORM OF CROSS-SECTION.

This shows that the efficiency is independent of the form of cross-section of the filament and depends only upon its temperature, the specific radiating power of its surface and the temperature of the surrounding space.

When we find, therefore, that one lamp is more efficient than another we must infer, not that it is on account of larger or smaller size, not because it is on a series or on a multiple circuit, not that it is because it has high or low resistance, or a certain form of cross-section, but that it is at a higher temperature, or is made of material having a different specific radiating power.

FORMS OF CROSS-SECTION.

Of all possible forms of cross-section the circular has the largest area for the same radiating surface per unit of length, and, consequently, has the advantage of great strength. The current density will also be less in this than any other form; and hence, any "disintegrating" or "electrolytic effect" of the current, if there is any such, will be least in the cylindrical filament. This will be made clear by supposing a number of lamps of equal candle-power to be burning at the same temperature and pressure, but having various forms of filament, cylindrical, flat, square, etc. We have already seen that these lamps all consume equal amounts of energy, and since they have the same pressure, they must take the same current. Therefore, the filament which has the greatest area of cross-section will have the least current density. The fact that the cylindrical filament has the greatest cross-section does not signify that it will require a greater current to keep it at the same temperature. Its form is better adapted for retaining heat than any other. Again, the several lamps will have equal resistances; otherwise they could not take equal currents with the same pressure. From this it follows that the cylindrical filament will be longer and will have less surface and greater mass per unit of length than any other.

A tubular filament would have a greater external diameter, but smaller cross-section of material, and would be shorter than the cylindrical.

The advantages and disadvantages of the various forms may be summed up as follows:—

The cylindrical has the advantage of greater strength and less current density on account of greater cross-section. It has the disadvantage of greater length and fragility.

The tubular filament is strongest in form, being shorter and of greater external diameter than the cylindrical. It has the disadvantage of greater current density than the cylindrical. Both the tubular and the cylindrical have the advantage of uniform illumination in all directions except in and near the plane of the filament.

Flat, or angular filaments have the disadvantage of great current density, and of being unequally heated, since

either in the process or in the dimensions. The writer has examined a number of different makes of lamps, and found that they generally vary in length and cross-section enough to produce serious differences in temperature.

ANOTHER EXAMPLE.

Suppose, again, we wish to construct a 50-candle lamp for a series circuit of 5 amperes:

$$C = 50.$$
$$c = 5.$$

From (20)

$$E = 3.75 \times \frac{50}{5} = 37.5 \text{ volts}$$

from (9)

$$r = .098466 \sqrt[3]{(5)^2} = .28792 \text{ millimeter}$$

from (11)

$$L = 6.419 \times 37.5 \sqrt{.28792} = 129.16 \text{ millimeters}$$

from (4)

$$R = .0048134 \frac{129.16}{(.28792)^2} = 7.5 \text{ ohms.}$$

In this case the loss of heat by conduction through the connecting wires is considerable, and must be taken into account.

OTHER APPLICATIONS.

The above equations are not limited to incandescent filaments, but apply equally to any conductor which may be kept at a certain fixed temperature by an electric current. By using the proper constants, useful formulæ may be derived for calculating conductors, so that under given conditions they will be heated to a required temperature.

ON THE PROPAGATION OF ELECTRIC WAVES THROUGH WIRES.[1]

BY PROFESSOR H. HERTZ.

If a constant electric current flows in a cylindrical wire, its intensity is the same in all parts of the section of the wire. But if the current is variable, self-induction causes a deviation from this most simple distribution. For, since the inner parts of the wire are in the mean less distant from all the rest than are those on the circumference, induction opposes alterations of the current in the interior of the wire more strongly than at the circumference; and in consequence of this the flow is confined to the exterior of the wire. If the current alters its direction a few hundred times per second the deviation from the normal distribution is no longer imperceptible; this deviation increases rapidly with the rate of alternation, and when the current alternates many millions of times per second, according to theory almost the whole interior of the wire must appear free from current, and the flow must be confined to the immediate neighborhood of the circumference. In such very extreme cases the hitherto accepted theory of the phenomenon is plainly not without physical difficulties; and preference must be given to another view of the subject, which was indeed first put forward by Messrs. Heaviside[2] and Poynting[3] as the true interpretation of the equations of Maxwell as applied to this case. According to this view, the electric force which determines the current is in no wise propagated in the wire itself, but under all circumstances enters the wire from without and spreads itself in the metal comparatively slowly, and according to similar laws as changes of temperature in a conductor of heat. If the forces in the neighborhood of the wire are continually altering in direction, the effect of these forces will only enter to a small depth into the metal; the more slowly the changes take place, so much deeper will the effect penetrate; and if, finally, the changes follow one another infinitely slowly, the force has time to fill the whole interior of the wire with uniform intensity.

In whatever way we wish to regard the results of the theory, an important question is, whether it agrees with fact. Since, in the experiments which I carried out on the propagation of electric force, I made use of electric waves in wires which were of extraordinarily short period, it was convenient to prove by means of these the accuracy of the inferences drawn. In fact, the theory was proved by the experiments which will now be described; and it will be found that these few experiments suffice to confirm in the highest degree the view of Messrs. Heaviside and Poynting. Analogous experiments, with similar results, but with quite different apparatus, have already been made by Dr. O. J. Lodge,[4] chiefly in the interest of the theory of lightning conductors. Up to what point the conclusions are just which were drawn by Dr. Lodge in this direction from his experiments must depend in the first place on the velocity with which the alterations of the electrical conditions really follow each other in the case of lightning.

The apparatus and methods which are here mentioned are those which I have described in full in previous memoirs.[5] The waves used were such as had in wires a distance of nearly three meters between the nodes.

1. If a primary conductor acts through space upon a secondary conductor, it cannot be doubted that the effect penetrates the latter from without. For it can be regarded as established that the effect is propagated in space from point to point, therefore it will be forced to meet first of all the outer boundary of the body before it can act upon the interior of it. But now a closed metallic envelope is shown to be quite opaque to this effect. If we place the secondary conductor in such a favorable position near the primary one that we obtain sparks five to six millimeters long, and surround it now with a closed box made of zinc plate, the smallest trace of sparking can no longer be perceived. The sparks similarly vanish if we entirely surround the primary conductor with a metallic box. It is well known that with relatively slow variations of current the integral force of induction is in no way altered by a metallic screen. This is, at the first glance, contradictory to the present experiments. However, the contradiction is only an apparent one, and is explained by considering the duration of the effects. In a similar manner a screen which conducts heat badly protects its interior completely from rapid changes of the outside temperature, less from slow changes, and not at all from a continuous rising or lowering of the temperature. The thinner the screen is the more rapid are the variations of the outside temperature, which can be felt in its interior. In our case also the electrical action must plainly penetrate into the interior, if we only diminish sufficiently the thickness of the metal. But I did not succeed in attaining the necessary thinness in a simple manner; a box covered with tinfoil protected completely, and even a box of gilt paper, if care was taken that the edges of the separate pieces of paper were in metallic contact. In this case the thickness of the conducting metal was estimated to be barely $\frac{1}{20}$ millimeter. I now fitted the protecting envelope as closely as possible round the secondary conductor. For this purpose its spark-gap was widened to about 20 millimeters, and in order to detect electrical disturbances in it an auxiliary spark-gap was added exactly opposite the one ordinarily used. The sparks in this latter were not so long as in the ordinary spark-gap, since the effect of

1. From the *Phil. Mag.* for August. Translated from Wied. *Ann.*, xxxvii., p. 395 (July, 1889), by Dr. J. L. Howard, Demonstrator of Physics in University College, Liverpool.

2. Oliver Heaviside, *The Electrician*, Jan. 1885; *Phil. Mag.* [5], xxv., p. 153 (1888).

3. J. H. Poynting, *Phil. Trans.*, ii., p. 277 (1885).

4. Lodge, *Journ.* Soc. Arts (May, 1888); *Phil. Mag.* [5], xxvi., p. 217 (1888).

5. Hertz, Wied. *Ann.*, xxxiv., p. 551 (1888).

wire in whichever direction waves were sent through the apparatus. So far, then, this arrangement promises nothing new, but it has the advantage over the previous one that we can replace the protecting metallic tube, γ, by tubes of smaller and smaller thickness of wall, in order to investigate what thickness is still sufficient to screen off the outside influence. Very thin brass tubes, tubes of tinfoil and Dutch metal proved to be perfect screens. I now took glass tubes which had been silvered by a chemical method, and it was then perfectly easy to insert tubes of such thinness that, in spite of their protecting power, brilliant sparks occurred in the central wire. But sparks were only observed when the silver film was no longer quite opaque to light and was certainly thinner than $\frac{1}{100}$ millimeter. In imagination, although not in reality, we can conceive the film drawn closer and closer round the wire, and finally coinciding with its surface; we should be quite certain that nothing would be radically altered thereby. However actively, then, the real waves play round the wire its interior remains completely at rest; and the effect of the waves hardly penetrates any more deeply into the interior of the wire than does the light which is reflected from its surface. For the real seat of these waves we ought not to look, therefore, in the wire, but rather to assume that they take place in its neighborhood; and instead of asserting that our waves are propagated in the wire, we should be more accurate in saying that they glide along on the wire.

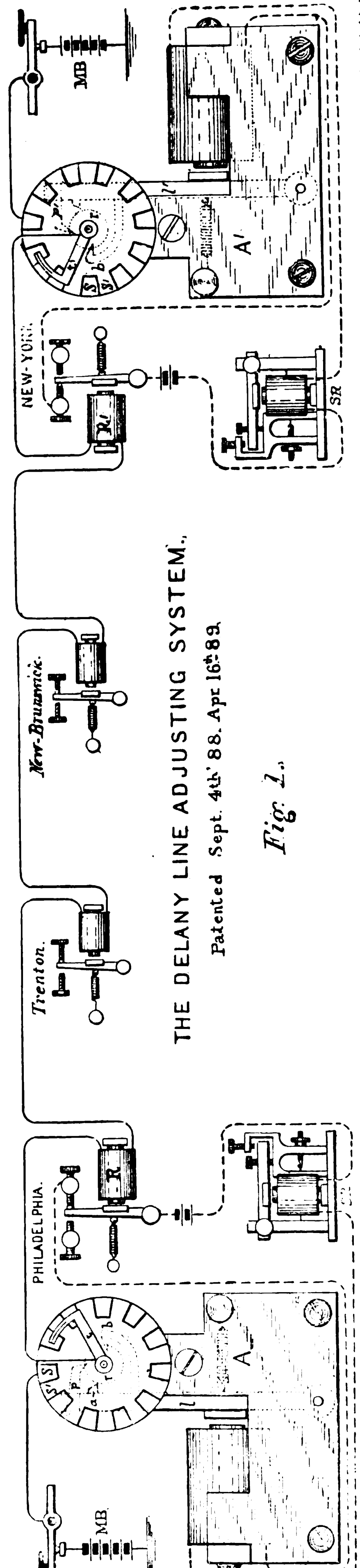
Instead of placing the apparatus just described in the circuit in which we introduced waves indirectly, we can insert it in one branch of the primary conductor itself. In such experiments I obtained results similar to the previous ones. Our primary oscillation, therefore, takes place without any participation of the conductor in which it is excited, except at its bounding surface; and we ought not to look for its existence in the interior of the conductor.[6]

To what has been said above about waves in wires we wish to add just one remark concerning the method of carrying out the experiments. If our waves have their seat in the neighborhood of the wire, the wave progressing along a single isolated wire will not be propagated through the air alone; but since its effect extends to a great distance it will partly be transmitted by the walls, the ground, etc., and will thus give rise to a complicated phenomenon. But if we place opposite each pole of our primary conductor in exactly the same way two auxiliary plates, and attach a wire to each of them, carrying the wires straight and parallel to each other to equal distances, the effect of the waves makes itself felt only in the region of space between the two wires. The wave progresses solely in the space between the wires. We can thus take precautions to propagate the effect through the air alone or through another insulator, and the experiments will be more convenient and free from error by this arrangement. For the rest, the lengths of the waves are nearly the same in this case as in isolated wires, so that with the latter the effect of the disturbing causes is apparently not considerable.

3. We can conclude from the above results that rapid electric oscillations are quite unable to penetrate metallic sheets of any thickness, and that it is, therefore, impossible by any means to excite sparks by the aid of such oscillations in the interior of closed metallic screens. If, then, we see sparks produced by such oscillations in the interior of metallic conductors, which are nearly, but not quite, closed, we shall be obliged to conclude that the electric disturbance has forced itself in through the existing openings. This view is also correct, but it contradicts the usual theory in some cases so completely that one is only induced by special experiments to give up the old theory in favor of the new one. We shall choose a prominent case of this kind, and by assuring ourselves of the truth of our theory in this case, we shall demonstrate its probability in all other cases. We again take the arrangement which we have described in the previous section and drawn in figure 1; only we now leave the protecting tube insulated from the central wire at δ. Let us now send a series of waves through the apparatus in the direction from A towards δ. We thus obtain brilliant sparks at A; they are of similar intensity to those obtained when the wire was inserted without any screen. The sparks do not become materially smaller, if, without making any other alteration, we lengthen the tube γ considerably, even to four meters. According to the usual theory it would be said that the wave arriving at A penetrates easily the thin, good-conducting metal disk a, then it leaps across the spark-gap at A, and travels on in the central wire. According to our view, on the contrary, we must explain the phenomenon in the following manner:—The wave arriving at A is quite unable to penetrate the metallic disk; it therefore glides along the disk over the outside of the apparatus and travels as far as the point δ, four meters away. Here it divides: one part, which does not concern us at present, travels on immediately along the straight wire, another bends into the interior of the tube and then runs back in the space between the tube and the central wire to the spark-gap at A, where it now gives rise to the sparking. That our view, although more complicated, is still the correct one, is proved by the following experiments:—Firstly, every trace of sparking at A disappears as soon as we close the opening at δ, even if it be only by a stopper of tinfoil. Our waves have only a wave length of three meters; before their effect has reached the point δ the effect at A has passed through zero and changed sign. What influence, then, could the closing of the distant end δ have upon the spark at A, if the latter really happened immediately after the passage of the wave through the metallic wall? Secondly, the sparks disappear if we make the central wire terminate inside the tube γ, or at the opening δ itself; but they reappear when we allow the end of the wire to project even 20 to 30 centimeters only beyond the opening. What influence could this insignificant lengthening of the wire have upon the sparks in A, unless the projecting end were just the means by which a part of the wave breaks off and penetrates through the opening δ back into the interior? Thirdly, we insert in the central wire between A and δ a second spark-gap B, which we also completely cover with a gauze cage like that at A. If we make the distance of the terminals at B so great that sparks can no longer pass across, it is also no longer possible to obtain visible sparks at A. But if we hinder in like manner the passage of the spark at A, this has scarcely any influence on the sparks in B. Therefore the passage of the spark at B determines that at A, but the passage of a spark at A does not determine that at B. The direction of propagation in the interior is therefore from B towards A, and not from A to B.

We can moreover give further proofs, which are more convincing. We may prevent the wave returning from δ to A from dissipating its energy in sparks, by making the spark-gap either vanishingly small or very great. In this case the wave will be reflected at A, and will now return again from A towards δ. In doing so, it must meet the direct waves from δ to A and combine with them to form stationary waves, thus giving rise to nodes and ventral segments. If we succeed in proving their existence, there will be no longer any doubt as to the truth of our theory. For this proof we must give somewhat different dimensions to our apparatus in order to be able to introduce electric resonators into its interior. I therefore led the central wire through the axis of a cylindrical tube five meters long and 30 centimeters diameter. It was not constructed of solid metal, but of 24 wires arranged parallel to each other along the generating surface, and resting on seven equidistant and circular rings of strong wire, as shown in figure

6. The calculation of the self-induction of such conductors on the assumption of uniform density of current in their interior must therefore lead to quite erroneous results. It is to be wondered at that the results obtained with such wrong assumptions should still appear to approximately coincide with truth.



THE DELANY LINE ADJUSTING SYSTEM.
Patented Sept. 4th '88. Apr 16th 89.
Fig. 1.

low adjustment to a high one. When they are sending, their relay armatures and sounder levers respond promptly to the manipulation of the keys, making the work much easier.

I will now explain how great improvement may be effected in the operation of telegraph lines having any considerable number of way stations. I claim that this improvement is almost as necessary to a railroad despatching wire as the air brake is to the train. It gives the despatcher control of all his operators, prevents interruptions and delays, and, if the line can be worked between the terminal stations, all the intermediate offices will be in perfect working order, and their instruments will work as well in bad weather as in good. Operators cannot then evade responsibility for neglect or seek refuge behind the excuse that their instruments are out of adjustment on account of the bad condition of the line.

Figure 1, shows a line from New York to Philadelphia, with New Brunswick and Trenton as way stations. There might be 40 stations, but these suffice for illustration. The figure shows the ordinary outfit for closed circuit, single current working, as used almost exclusively in this country. A and A′ are the *adjusters.* This instrument consists of a magnet, armature lever, *l*, pawl, *p*, and stops, *a* and *b*, ratchet wheel, *r*, on the shaft which carries the trailing finger, *t*, and the circle of segments. Alternating segments are joined to a common plate. Set S forms part of the circuit, while set S′ are not connected, but simply serve to make a smooth track for the trailing finger. Beginning at the Philadelphia end, the circuit may be easily traced from main battery MB and key to segment plate S, upon which trailer *t*, rests. From the trailing finger to relay R, through relays at Trenton and New Brunswick to New York, where it goes from relay R′ to trailer *t′*, segment plate S, to key, main battery MB, and to earth. The adjuster magnets are in the local circuit with the sounders SR. Figure 2, is a diagrammatic view of the switch connections of the adjuster for throwing it in or out of use, as the state of the line may require. MM are the main line wires, LL the locals.

Suppose the weather is fine and the line clear. The switch will be thrown to the left—and the adjuster out of use, the line being connected outside of the trailer and segments, while a small resistance coil, shown on the switch, will be substituted for the adjuster magnet in the local circuit, the battery of which, on account of the adjuster, is increased from two gravity cells to five. Now if a rain storm comes on, an intermediate earth route for the main batteries at New York and Philadelphia is established, and trouble with the adjustment of all the intermediate relays begins. If the escape be evenly distributed, Trenton will hear Philadelphia on a lower adjustment than that required for hearing New York, while New Brunswick will get New York on a lower adjustment than is necessary for receiving signals from Philadelphia. An office in the middle of the line would, if the main batteries were of equal strength, get New York and Philadelphia on the same adjustment, but with greatly diminished current. Ordinarily, there is a considerable margin of adjustment. I would not be understood to state that in all cases a radical change of adjustment is necessary. It will depend on the length of the line, the number of intermediate relays in the circuit, and the severity of the storm, or the general condition of the circuit prevailing at the time.

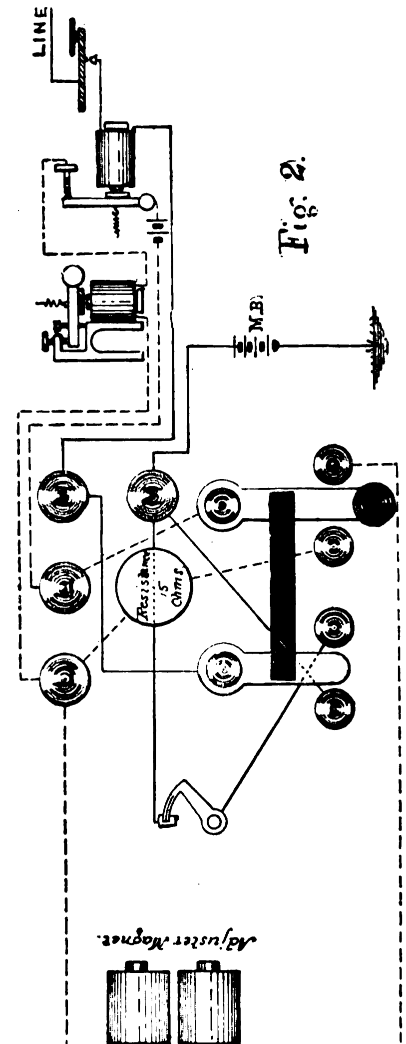


Fig. 2.

But on all way wires vexatious interferences and delays begin as soon as a storm sets in ; New York might be calling Trenton, while Trenton, unconscious of the fact, might be calling New York. When a few careless or inexperienced operators let themselves loose on a long line during bad weather, the service is practically paralyzed. One such operator may monopolize the line for hours, and it sometimes happens that two of them, thinking the line idle, strike up conversation, which an unappreciative and disgusted audience of their fellows along the line must listen to while messages of life and death are awaiting transmission. Furthermore, operators cannot read so well

THE DANGERS OF ELECTRIC LIGHTING.[1]

BY THOMAS A. EDISON.

So much has of late been said and written upon the subject of high-tension electric currents and their probable or possible danger to human life, and so many different opinions have been advanced by men whose positions serve to surround their utterances with an atmosphere of knowledge of the matter under discussion, that the mind of an unscientific public has been unable to come to any definite conclusion upon the basis of "expert" testimony. It is most unfortunate that a practical demonstration in support of the real facts of the case could not have been made in a less tragic manner than was witnessed a few days ago in New York by several thousand people; and yet if the martyrdom of this poor victim results in the application of stringent measures for the protection of life in the future, if the lesson taught is appreciated to the full extent of its fatal meaning, the sacrifice will not have been made in vain. With the increase of electric lighting (which to-day is used only to a very limited extent as compared with its inevitable future use) and the multiplication of wires, these dangers which exist now in a thousand different parts of the city will be manifolded many times. In fact, the opportunities for repetitions of the accident referred to above will be practically unlimited.

I can write upon this subject only as one convinced. I cannot discuss it otherwise. The public would scarcely be interested in the details leading up to the position taken by myself and the conclusions to which I have come, for the reason that it would involve a mass of matter such as they have been attempting to digest during several months past; and, instead of explaining, I might succeed only in adding to the present confusion of popular ideas. But I may say that I have not failed to seek practical demonstration in support of such facts as have been developed, and I have taken life—not human life—in the belief and full consciousness that the end justified the means.

The currents used for electric lighting at the present time may generally be divided into four classes :—

First—The low-tension continuous current, with a pressure not exceeding 200 volts, used for incandescent lighting.

Second—The high-tension continuous current, with a pressure of 2,000 volts and over.

Third—The high-tension semi-continuous current, with a pressure of 2,000 volts and over.

Fourth—The alternating current, with a pressure from 1,000 to 3,000 volts and over.

The first is harmless, and can be passed through the human body without producing uncomfortable sensations. The second is dangerous to life. Momentary contact with a conductor of the third results in paralysis or death, as has frequently occurred; and the passage of the fourth, or alternating current, through any living body means instantaneous death.

These are simple facts which cannot be disproved. There is a record of nearly one hundred deaths, which furnishes an unanswerable argument in support of these statements. Discussion and controversy may serve the questionable purpose of delaying popular faith in them, but they cannot change them; and the sooner they are accepted and acted upon the less liability will there be of a recurrence of the late horror, which is still fresh in the minds of all those who witnessed or read of it.

It has often been asked why the number of accidents of this nature is larger in the City of New York than in any other city. The reason is that New York has a greater number of wires to the square mile than any other city in the United States. The percentage of deaths in other places will reach that of New York when wires are strung in like numbers; but if electric lighting under its present conditions extends in the latter city proportionately, its death rate will have been greatly multiplied by the time other cities reach its present high percentage.

Many suggestions have been made as to the best way in which to remedy the existing evil, and the popular cry seems to be, "Put the wires underground." But, instead of diminishing, this will increase the danger to life and property. There is no known insulation which will confine these high-tension currents for more than a limited period, and when they are placed beneath the ground, with the present system of conduits, the result will be a series of earth-contacts, the fusion of wires, and the formation of powerful electric arcs, which will extend to other metallic conductors in the same conduit, and a whole mass of wires made to receive this dangerous current and convey it into houses, offices, stores, etc. It is thus evident that the dangers of such circuits are not confined to the wires which convey the high-tension currents, but other wires conducting harmless currents are liable to be rendered as deadly in effect as the former. It is evident, also, that a single wire carrying a current at high pressure would be a constant menace to the safety of all other wires in the same conduit. Even though these dangerous wires be placed in separate tubes in the same conduit with other tubes, the risk is not diminished.

Several instances are on record, and one I have particularly in mind, showing the possibility of serious accident through the crossing of wires. Near the corner of William and Wall streets, New York, the underground conductors of the Edison Illuminating Co. became crossed, and the current which was passing through them at a pressure of only one hundred and ten volts melted not only the wires, but several feet of iron tubing in which they were incased, and reduced the paving stones within a radius of three or four feet to a molten mass. This system is so arranged that consumers are not affected by such accidents as this. They may and do mean expense to the company, but the public are entirely free from any possibility of danger. The crossing of wires in this way means the concentration of several hundred horse-power of energy in a small space. What would have been the effect of such a cross as I have described had the pressure been two thousand instead of one hundred and ten volts? and what also might be the effect were it to occur in a conduit in close proximity to hundreds of telephone wires and those of other electric lighting systems? The risk, too, is greatly increased by the fact that consumers who are supplied with currents from a low tension system are accustomed to handle their electrical appliances freely, knowing them to be harmless. If these are to be rendered at any moment dangerous to life, the result will be appalling. I say nothing of the injustice to vendors of harmless supplies of electricity.

So far, the deaths which have occurred from this source have been chiefly confined to employés of electric lighting and telegraph companies—men whose duties have required them to work in close proximity to the conductors of these death-dealing currents. It is true that a number of accidents, many of them attended with fatal results, have occurred to pedestrians on the streets of New York and other cities through the medium of fallen wires; but the risk incurred by the general public with the present system is really less than it would be if these dangerous conductors were placed in closer proximity to the ground. As the earth is approached the danger is multiplied. The connection and crossing of two wires by a line of moisture or liquid contact are just as effective as the contact of one wire with another when overhead.

That this error of judgment is not confined to the public, but is shared in by the officials of the City of New York, is made apparent by a resolution of the Mayor offered at a meeting of the Board of Electrical Control on Monday, October 14, and which is reported in the following form:—

> That the numerous deaths caused by the electric light and power wires within the last thirty days, and the shocking manner in which they have occurred, furnish ample and sufficient proof

1. From the *North American Review*, November, 1889.

that such wires are not being placed underground with a speed sufficient to insure the safety of the lives of the people of this city, etc., etc.

The logical inference here is that the lives of the people will be safe as soon as the wires have been placed underground. If a nitro-glycerine factory were being operated in the City of New York and the people desired to remove the danger, no one would suggest putting it underground. When it became necessary for the protection of employés and of the public to regulate boiler pressures in the city, the authorities proceeded on lines entirely different from those which are being followed in connection with electrical pressures; and yet the cases are parallel, and the course of reasoning which resulted in a perfect system for the limitation of steam pressure and the periodical inspection of boilers should be retraced, and the principle applied to secure safety from a pressure which, uncontrolled as at present, is far more dangerous than the former was before steps were taken to render it harmless.

The insulation of a wire carrying a high tension current in the most perfect manner known may insure temporary safety; but time is bound to develop defects as the result of the action of the current upon the insulating material, of a change in the molecular structure of the material itself, and for other reasons. The pulsations or vibrations in an electric conductor cause corresponding vibrations in the insulation. So powerful is this effect that the insulation gives off a sound corresponding to the oscillation of the current. So long as the insulation retains its original elasticity, the current is confined; but the influence of the air, or of gas and other agents, tends to change the elasticity, and the billions of vibrations to which it has been subjected finally render it very susceptible of being pierced by a spark of static electricity. Thus an avenue for the ingress of moisture is formed, not only in one spot, but in many, through which the current may be communicated to any conductor of electricity near enough to make physical contact, or a circuit may be completed between the two by a line of moisture or the formation of an electric arc, with its subsequent destructive action.

The numerous accidents which have occurred in the City of New York during the past year show to a very large extent the operation of time upon the insulating material which surrounds these wires. When first erected, the current was to a certain extent successfully confined; but the air is doing its work, abrasions are more easily made, and, without the adoption of genuine methods of control, "accidents" may be looked for in larger numbers as time goes on, due not only to deterioration of insulation, but to the multiplying of electric circuits to supply the popular demand for electric light.

The public may rest absolutely assured that safety will not be secured by burying these wires. The condensation of moisture, the ingress of water, the dissolving influence of coal gas and air-oxidation upon the various insulating compounds will result only in the transfer of deaths to man-holes, houses, stores, and offices, through the agency of the telephone, the low pressure systems, and the apparatus of the high tension current itself.

I have no intention, and I am sure none will accuse me, of being an alarmist. When the possibilities of the future are viewed in the light of recent developments, it must be apparent to every one that the time has come when those in authority should adopt proper and adequate measures for the protection of life and property, and my familiarity with the subject enables me to see very clearly the only true remedy which can be applied—namely, the regulation of electrical pressures. Once these pressures are reduced to a point which is harmless, the public may retire in security and leave electricians to discuss the merits or demerits of various methods of insulating, the defects of which will only concern those interested in the commerce of electricity.

There is no plea which will justify the use of high tension and alternating currents, either in a scientific or a commercial sense. They are employed solely to reduce investment in copper wire and real estate. For instance, in arc lighting it is customary to put forty lamps on each circuit; each lamp requires a pressure of fifty volts; therefore the total pressure on the circuit is two thousand volts. Now, if, instead of using only one wire for all these lamps, four circuits of ten lamps each were to be established, the pressure on each wire would be only five hundred volts. The weight of copper necessary for these four circuits of ten lamps each would be two and a half times greater than for one circuit of forty lamps—a question, as I have said, simply of investment.

The alternating current under high pressure and direct-current high pressure systems are also employed, as I have intimated, to save investment in real estate as well as copper. If a certain district is to be supplied with electric light, the natural point from which the current should be distributed is the centre, with wires radiating toward the circumference of the circle of supply; and if, instead of including in any one of these districts an area so large that resort must be had to high pressure in order to reach its limits, the distributing power of a single station be confined to a capacity consistent with safety, and other centres sought from which to furnish current to other areas, the necessity for high electrical pressure vanishes. But real estate in such centres as these is expensive, and the promoters of electric lighting enterprises which spring into existence with the growth and stability of the mushroom, cannot afford to consider permanency, the security of the public, the requirements of small consumers, or any such questions, which would incidentally involve the investment of larger sums of money; but, seeking the outskirts of a district, where land is cheap, or some abandoned building available for sheltering a few dynamo machines, they run small wires to the area of supply, enormous pressure being necessary to force the current through these small conductors over such long distances.

In the last issue of *The Electrical World*, page 254, is recorded a series of experiments conducted by M. d'Arsonval, a member of the French Academy of Sciences, showing "the effects of continuous and alternating currents on animals." He says:—"A living being is, above all, sensible to a variable state of the current, from which it follows that at a mean equal pressure alternating currents are more dangerous than continuous currents;" and "with a battery of four hundred and twenty volts (continuous current) death is only caused by long-repeated interruptions of the current." In other words, the continuous current of the above pressure could not be made to cause death until it was interrupted or made discontinuous—or perhaps a better expression would be semi-continuous. By a variable state of the current is meant a fluctuation of pressure between different extremes of voltage. The human nerve system, up to a certain limit of pressure, cannot detect the flow of a continuous current if the voltage be perfectly constant. This constancy is obtained by multiplying the number of commutator bars on the dynamo. The brushes which are set upon the revolving commutator, and conduct the current from the machine to the outside system, rest alternately upon the different bars of the commutator. The greater the number of bars, the less will be the fluctuation of the current, which may be likened to a wave-motion, rising and falling, and producing that variable state referred to by the French scientist.

Nearly all dynamo machines used for arc lighting are constructed with an insufficient number of commutator bars to produce a steady continuous current. The ranges of variable pressure are not, however, nearly as great as in the alternating system. With respect to the latter, M. d'Arsonval says:—"An alternating Gramme machine caused death when above one hundred and twenty volts mean potential." This is a small unit to contemplate after the glib manner in which it has been recently stated that

this current is harmless at a pressure of one thousand volts. I have myself seen a large healthy dog killed instantly by the alternating current at a pressure of one hundred and sixty-eight volts. It is a simple matter to calculate the ranges of variable pressure in this system. The dynamo machine has no commutator. The armature or "bobbin" is wound in such a way that the whole of the current under a pressure, say, of two thousand volts, is sent out on the wire first in one direction, then is reversed and sent out at the same pressure in the other direction, or passes through the wire in the opposite direction; and these reversals are generally made about a hundred times in each second.

The variable state of a continuous current at a pressure of two thousand volts means ordinarily a rise from zero point up to two thousand, after which, owing to the action of the commutator, it varies between, say, seventeen hundred and two thousand, while the variable state of the alternating current means a fluctuation from two thousand volts above the zero point to two thousand below it, or a difference of four thousand volts. The danger to life is probably proportionate to the fluctuation of pressures. When an alternating current of fifteen volts is applied to a human being in the most effective manner, the effect upon the nerve system is so violent and the pain produced so great that it is absolutely impossible for any one to stand it.

As I have said before, the only way in which safety can be secured is to restrict electrical pressures. The continuous current should be limited to six hundred or seven hundred volts, with a variable range not exceeding a few volts. As for the alternating current, it is difficult for me to name a safe pressure. Its effect upon muscular action is so great that even at exceedingly low voltage the hand which grasps a conductor cannot free itself, and it is quite possible that in this way the sensitive nervous system of a human being could be shocked for a sufficient length of time to produce death. The electric lighting company with which I am connected purchased some time ago the patents for a complete alternating system, and my protest against this action can be found upon its minute book. Up to the present time I have succeeded in inducing them not to offer this system to the public, nor will they ever do so with my consent. My personal desire would be to prohibit entirely the use of alternating currents. They are as unnecessary as they are dangerous. In the City of New York there are many miles of conductors beneath the streets conveying a harmless continuous electric current to thousands of consumers, the maximum pressure on this vast system never exceeding two hundred and twenty volts, which will force so weak a current through the human body that it can barely be detected. Furthermore, it is found to be commercially successful, and I can therefore see no justification for the introduction of a system which has no element of permanency and every element of danger to life and property. This is no argument in favor of monopoly. If ever there is to be a monopoly of electric lighting in the United States, it will be neither delayed, prevented, nor circumnavigated by such subterfuges as these alternating systems, and their use cannot be justified on that score. I have always consistently opposed high-tension and alternating systems of electric lighting (although perfectly free to use them), not only on account of danger but because of their general unreliability and unsuitability for any general system of distribution.

In contemplating the efforts of the officials of the City of New York to remedy the evils connected with electric lighting, I have been impressed in a way which must have impressed other on-lookers. I refer to the apparent difficulty of determining where the authority to take action rests. The hands of those who wish to act appear to be tied, which is unfortunate, considering the exigencies and urgency of the case. In England they handle these matters better. The Electric Lighting Act of 1882 provides in section 6,

that the Board of Trade may from time to time make such regulations as they may think expedient for securing the safety of the public from personal injury or from fire or otherwise, * * * and any regulations so made or amended by the Board of Trade shall from and after the date thereof have the like effect in every respect as though they had been originally inserted in the license, order, or special act authorizing the undertaking.

This same section also provides that

any local authority within any part of whose district electricity is authorized to be supplied under any license, order, or special act, may, in addition to any regulations which may be made under the preceding provisions of this section for securing the safety of the public, from time to time, make, rescind, alter, or repeal by-laws for further securing such safety; and there may be annexed to any breach of such by-laws such penalties to be recovered in a summary manner as they may think necessary. Provided always that no such by-laws shall have any force or effect unless and until they have been confirmed by the Board of Trade and published in such manner as the Board of Trade may direct.

Thus to a responsible body is given discretionary power for the protection of the public, and local authorities (by which is meant any municipality) have the right to apply to this board for relief from any danger which they believe to exist in connection with electric lighting systems. Certainly, the responsibility for the protection of the people of our city should be as definitely placed, and those to whom such authority is given should adopt rigid rules for the restriction of electrical pressures. Perhaps police control would be even more adequate than the English system. I am not altogether familiar with the details of the system of boiler inspection which prevails in New York, but I believe it is very efficient and would serve as an excellent model for the case under discussion.

When the authorities require electrical pressures to be kept within the limits of safety, and when there is an efficient corps of inspectors, as in the case of boilers, to see that the rules adopted are carried out, the security which the public demand will be attained; but until then nothing better can be looked for than a multiplication of the casualties of the past few months.

SHALL HIGH TENSION CURRENTS BE PROHIBITED?

BY GEORGE B. PRESCOTT, JR.

WHEN a specialist of the world-wide renown of Thomas A. Edison expresses his opinion upon a matter of great public importance, relating to the science which has chiefly occupied his remarkable talents, it deserves respectful attention and thoughtful consideration. In his article on "The Dangers of Electric Lighting," in the November number of the *North American Review*, it seems to me that he who is often called the most progressive man of the age, cries halt to progress.

Mr. Edison takes the ground that high tension and alternating currents of electricity are dangerous to life; that they cannot be safely controlled; and that they possess no calculable advantages over low tension direct currents, except that of requiring a somewhat smaller investment of capital. Notwithstanding his arguments, I am still compelled to believe that Mr. Edison's opposition to the employment of high tension and alternating currents in electrical distribution is neither consistent with his past record, nor based on progressive ideas. In saying that his position is not consistent, I mean that it is not in harmony with his actual work in incandescent lighting, inasmuch as almost every important improvement made by him in this field has heretofore been in the direction of utilizing higher tension currents than had been employed by others. That his position is not based on progressive ideas is an obvious fact. It is a scientific and practical truism that the distribution of large amounts of any kind of energy to great distances can be economically effected only at high pressures. When Edison had largely perfected the primary structure

ABSTRACTS AND EXTRACTS.

THE SPIRAL COIL VOLTAMETER.[1]

BY HARRIS J. RYAN.

DURING the present year at the Physical Laboratory of Cornell University, the copper voltameter has been used somewhat extensively in laboratory practice by students, for calibrating Thomson graded galvanometers, tangent galvanometers, and other electrical measuring instruments where a single determination suffices as a calibration. For practical instruction students are made to check their results on a Thomson gravity balance, and by means of the large galvanometer at the Magnetic Observatory.

The plate form of copper voltameter has been thoroughly and admirably investigated by Mr. Thomas Gray,[2] of the Physical Laboratory of the University of Glasgow. We are indebted to Mr. A. W. Meikle[3] and to Lieutenant Anderson[4] for clear descriptions, based upon the results of Mr. Gray, for the use of this form of voltameter, whereby determinations may be made so accordant that one can scarcely think of more to be desired.

With all this, however, it has been our experience that students are slow to obtain accordant results when making their first attempts to follow Mr. Gray's methods. It seemed desirable to make use of a form of voltameter that required the least consistent time and care to construct and prepare for operation. Again, there should be a wide allowable range of current density, through which deposits would be as firm and adherent as possible. It was with a view of realizing this that we finally adopted and made use of the spiral coil form herein described.

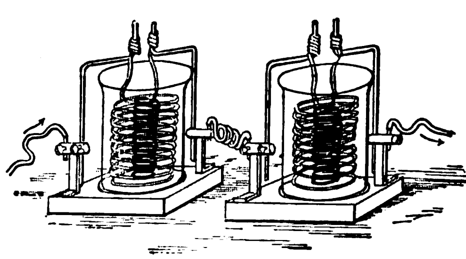


FIG. 1.

A wire coil as a cathode seemed to present many advantages. Wire of high conductivity, good for this purpose, is generally available in any desired size. A wire can be cleaned properly with great ease and readiness by fastening one end in a vice, holding the free part in one hand and sand-papering it with the other. By beginning at the vice to clean it is not necessary to touch the cleaned wire with the hands throughout the complete operation of polishing and coiling into a spiral on a cylinder of the proper diameter, about which has been rolled clean paper. In this manner gain and loss coils are constructed.

Figures 1 and 2 show the final form of voltameter adopted. The coils are hung vertical. The cathode is made of a smaller diameter and is arranged inside and concentric with the anode. The diameter of the anode is made about 3 cm. to 4 cm. larger than that of the cathode. The loss coils prepared as above are ready for use, since for well-known reasons their changes of weight are never accordant. The surface of the gain coil must not be touched by the hand. It is easy to handle it by the extending terminal, by means of which it is suspended in the voltameter. After polishing it is washed by plunging into a jar of water containing a little H_2SO_4.

It is then rolled on filter or blotting paper to remove all but a mere film of the water. The coil is then dipped in 95 per cent. of alcohol, removed and the excess of alcohol allowed to drip into the jar of the same. By rolling the coil on clean filter or blotting paper again, nothing but a mere film of alcohol remains, and that is thoroughly evaporated in a few moments, leaving the coil entirely dry.

Coils that have been laid away and become corroded can be readily cleaned, as is well known and directed, by plunging them into a mixture of strong HNO_3 and HCl, 100 parts of the former to one of the latter, removing them quickly to a distance, such that the vapors of the acid shall not reach the coil during the rest of the preparation. This consists in washing first thoroughly in water, and then proceeding as at first described by plunging in the acidulated water, alcohol, etc. After weighing the coils are ready for the voltameter.

It has been customary with us to use a coil made of two and one-half meters of No. 16 wire, having the surface area of 100 square centimeters.

For great strengths of current a number of these are arranged in parallel.

For every four amperes one wire is necessary. At the end of the deposit the gain coils are immediately removed, and plunged first into clean water and then into the acidulated, from which they are dried by means of alcohol in the manner above described. When dried they are at once ready to weigh.

The copper sulphate, water and acid, need not necessarily be chemically pure. The density of the voltameter solution should be not less than 1.10 and not more than 1.18.

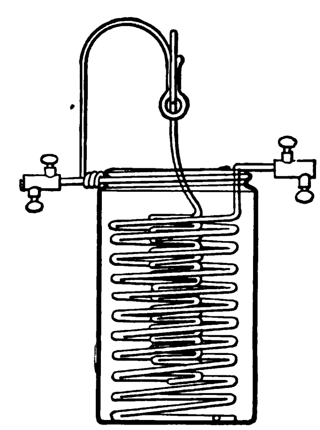


FIG. 2.

The question now comes to us as to what degree of accuracy and precision of results we may depend upon from the above form of voltameter.

The successful use of the copper voltameter has come from an appreciation and an understanding of the fact that when copper is immersed in an acidulated solution it passes slowly into solution in an irregular way. Mr. Gray has done much work in this particular, and has shown that the going into solution of copper on the cathode is curiously assisted by the current. From the extensive work done with the plate form of voltameter at Glasgow, results have been gained with regard to the amount of copper that goes into solution for a certain current density and a certain temperature, that it is a comparatively easy thing to make determinations with assured absolute accuracy to within a 10th or even a 20th of one per cent. This is remarkable, though nevertheless true.

A Thomson deca-ampere balance was calibrated by means of the copper voltameter under Mr. Gray's directions at Glasgow.

When the same was received and set up at Ithaca in the physical laboratory of the University, it was compared with the large standard tangent galvanometer at the Magnetic Observatory, and found to agree with the same to within one-tenth per cent.

Surely this same or even a greater degree of absolute accuracy could be obtained with less trouble and experience

1. A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.
2. *Phil. Mag.* 1886 and 1888.
3. *Lond. Elec. and Elec. Review.*
4. N. Y. *Elect'n*, October, 1888.

by one making use of the spiral coil cathodes. Mr. Gray has shown that if copper went into solution, unaided by the current, that we could in almost all cases neglect this correction. He has shown us how much it is when a plate is used as a cathode. There are strong reasons, however, for believing that when a wire, which presents a regularly curved surface, is used as a cathode, that the copper from it goes into solution in a more regular way, and that probably in all cases to a considerably less degree. Again, by the use of the spiral coil in a voltameter we find an advantage in the fact that the plane of each turn of wire is disposed horizontally, so that by convection the solution is not allowed to become weak near the cathode, nor dense near the anode.

This fact was first pointed out by Mr. Shaw, who speaks of the very accordant manner in which platinum wires disposed horizontally are found to act as cathodes in copper electrolysis.

In a valuable paper by Mr. Shaw[5] on "The Verification of Faraday's Law of Electrolysis with Reference to Silver and Copper," the very great range of current densities for

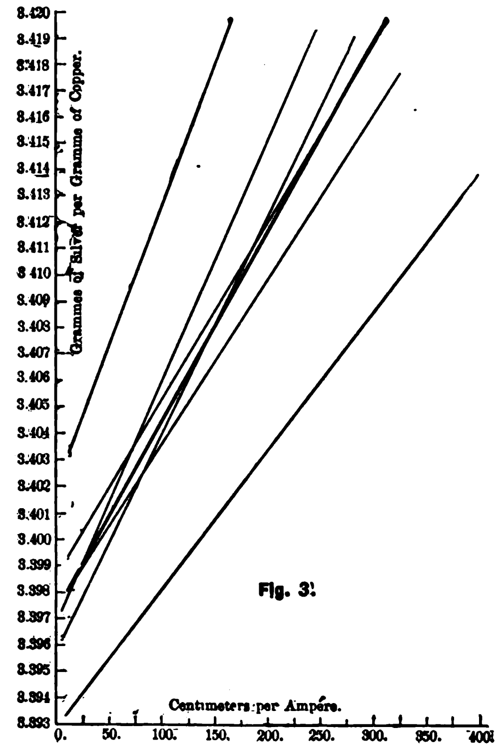


Fig. 3.

the deposition of copper on platinum wires of 8 cm. to 800 cm. per ampere has been brought to bear on the ratio of silver and copper deposits when the currents are the same. From data taken from this paper, the writer has plotted curves that show the relation of current density to copper deposit throughout Mr. Shaw's work at the Cavendish Laboratory and Emmanuel College.

The work extended over a year, and was done with much care. These curves are shown in figure 3. The ordinates represent the amount of silver deposited by the same current that deposits unit weight of copper in a given time, corresponding to current densities, as represented in square centimeters per ampere on the abscissæ axis. As is seen, with the exception of two, the curves are in remarkable accordance, differing by not more than 1.34 per cent. With regard to the two curves that fall above and below the rest, we would say that their position can easily be attributed to accidental causes; the error in the indications of the silver voltameter of a one-fifth of one per cent. either way would account for their position. Again, Mr. Shaw used no acid in the voltameter solution, a fact that will account for irregularities. Of these lines the heavy one was drawn as a fair average of them all. A glance at this line will derive some interesting results :—

We see that with a current density of 50 square centimeters per ampere the ratio of silver to copper deposited is 3.401. In the early part of Mr. Shaw's work, in a long series of observations, this same identical ratio as a mean for a mean current density the same as above was found.

Mr. Gray when at work on the same ratio determined the same identical value.

Finally, the writer has found that if we take the values for the chemical equivalents for silver and copper as quoted by Wurtz and those given by Meyer that the calculated values for this ratio are 3.401 and 3.399 to 3.401.

Therefore, since we know with great assurance the value of the electro-chemical equivalent of silver, we have an equal assurance that with a *current density of one ampere for every* 50 *square centimeters exposed the amount of copper deposited will be* .0003287 *grammes per coulomb.*

Again, we see that in a range of current density from 50 centimeters to 300 centimeters per ampere this line indicates a change in the amount of copper deposited from .0003287 to .0003270. It is to be remembered that these results were obtained by the use of a solution almost saturated and without acid. Returning to Mr. Gray's work we find that for the same range of current density the amount of copper deposit changes from .0003287 to .0003272 for a temperature at which Mr. Shaw probably worked.

It is well known that the copper goes into solution under the action of the current from the cathode at a much greater rate without acid than with, and especially at a greater rate when the solution is dense than when working under the proper conditions for measuring current. A comparison of Mr. Gray's and Mr. Shaw's results brought us to the belief that less copper should be dissolved from cathodes of the spiral coil form than those of the plate form.

To determine this, four cells were arranged by Mr. Gunning, a student in the sciences at Cornell. Two of these had cathodes and anodes of the plate form and the other two those of the "spiral coil" form. The large plate and coil and the small plate and coil had areas of 100 centimeters and 10 centimeters respectively. About half an ampere was passed through them for a time, amounting to two and one-half hours.

Every half hour they were taken out, dried and weighed, the solutions all intermixed, and the deposits continued for another half hour, etc.

The solution had a density of 1.1, and an addition of one-fourth per cent. acid. An examination of the intermediate results gives the same result that one gets by looking at the total gain of the coils and plates taken separately. Mr. Gunning's results were as follows :—

Temperature, 20 degrees.

Coils.		Plates.	
Small.	Large.	Small.	Large.
10 cm.	100 cm.	10 cm.	100 cm.
1.8220	1.8182.	1.8196	1.8136.

The result show that in going from a density of 20 centimeters to 200 centimeters per ampere, the amount of copper per coulomb changed from .0003289 to .0003283 for the coils, and for the plates, .0003285 to .0003275.

The result with the plates does not differ materially from that found by Mr. Gray for a similar range.

Mr. Gunning also made a number of comparisons of the spiral coil voltameter at different current densities, and at a mean temperature of 23 degrees centigrade, with the standard tangent galvanometer at the Magnetic Observatory. They were made with great care in every particular but one, and that was in the matter of time. This was taken from his own watch, that had not been compared with our standard chronometer. Again, to make and break the circuit, a large switch capable of carrying 250

5. British Association Meeting, 1886, N. Y. *Elect'n*, 1887.

amperes was operated, which added incidental errors, since the duration of each deposit was only 1,800 seconds; the results are interesting, because of their accordance and the manner in which they were obtained, and are given in the following table:—

Date.	Size.	Current.	Gain in grammes.		Grammes per ampere per hour.
			Coil No. 1.	Coil No. 2.	
May 8 & 9.	110 cm.	.6788	.3985	.3977	1.176
" " .	" "	1.312	.7699	.7704	1.177
" " .	" "	1.882	1.1060	1.1055	1.178
" " .	" "	2.446	1.4364	1.4372	1.178
" 6 & 7.	116 "	3.008	1.7686	1.7676	1.179
" " .	" "	3.532	2.0755	2.0753	1.179
" " .	" "	4.016	2.3639	2.3639	1.180
" " .	" "	4.495	2.6386	2.6326	1.176
" " .	" "	4.930	2.8932	2.8910	1.176
" " .	" "	5.263	3.0750	3.0808	1.173
" " .	" "	5.701	3.3437	3.3453	1.176
" 8 & 9.	110 "	6.492	......	3.7815	1.165*

* Deposit rough copper lost from both coils.

Fortenbaugh and West, also students in the laboratory, making use of a watch belonging to the former, known to the writer to have been keeping correct time, and otherwise precisely the same apparatus that Mr. Gunning used, obtained the following result:—

Duration	....	40 m.	
Current	....	1.314	
Coil No. 1 gained	....	1.036	Area,
" 2 "	....	1.035	90 sq. cm.

From this the number of grammes per ampere per hour is computed to be 1.182. And we know that for the above current density it should be 1.183. The galvanometer at the observatory is subject to a fluctuation in its indications by an amount that almost covers the above, due to variations of horizontal intensity throughout the succession of day and night.

The writer and Mr. E. G. Merritt, Fellow in Physics, Cornell University, hope to make a thorough investigation of the "spiral coil voltameter" in its use with silver and copper shortly.

From the ease with which those inexperienced in the use of the copper voltameter obtain consistent results, it was thought well to recommend its use in the meantime to others.

DISCUSSION.

Mr. Weston—For some years I had occasion to do a great deal of work with a copper voltameter, and I was finally compelled to give it up. I found it to be exceedingly unreliable; and no doubt part of that is due to the fact that the circulation of the electrolyte is not so perfect in some cases as in others. I should expect that the better operation of this voltameter, as compared with the plate voltameter, was largely due to the fact that the electrolyte circulated much more freely, and prevented the formation of secondary compounds and the deposition of them with copper. It is, I know, the general impression that copper goes down in an extremely pure condition when precipitated by the electric current. That is not a fact at all. The presence of extremely minute traces of organic matter in an ordinary electric bath will change the whole characteristics of the copper. One-tenth of one per cent. of the weight of the salt sulphate of copper of ordinary gelatine added to the solution will render the deposit absolutely useless for all practical purposes; so much so that it is almost as brittle as glass. If the density of the current is kept up where it was before the addition of the organic matter, great streaks of white material having a silvery lustre will manifest themselves on the electrodes. I do not think that anything has appeared in print in regard to that matter, but it certainly is a very interesting fact, and I think that the peculiar change in the physical properties of the copper so deposited is due to the formation of a peculiar body which was observed by the eminent French chemist, Wurtz, a few years ago, and which he called hydrite of copper. Therefore I have abandoned the copper voltameter. It requires considerable care not only in the preparation of electrodes to properly secure the accuracy to which Professor Nichols has shown it is capable of being brought, and it also requires care in the selection of the salt. Silver has been so thoroughly tested as to show that with proper care it is capable of giving excellent results.

Mr. Mailloux—I have had considerable experience with the deposition of copper, depositing it in very large quantities, and sometimes at very excessive rates, several times faster than is supposed to be possible, and sometimes at very slow rates. I have often noticed the discrepancy between the theoretical rate of deposit for a given amount of current and the actual results; in some cases, particularly where the rate of current was excessive, that discrepancy would be very great. Naturally this led to some inquiry as to the causes, and, I think, as the result of my observation and experience, that it is possible to get very accurate results with the copper voltameter. But in order to do so we should restrict ourselves to certain conditions or take them into consideration. In the first place, the copper used should be absolutely pure. Now, I have found repeatedly in depositing copper industrially, in electrotyping, for instance, or in electro-plating, that the character of the deposit, that is to say its physical properties as a metal, its ductility, etc., greatly depended on the character of the metal used as the anode. I think it was John T. Sprague, of England, who first pointed out that in depositing solutions there is always a tendency to deposit hydrogen, and it has been my experience that in depositing copper it is only under certain conditions that you are entirely free from depositing a certain amount of hydrogen with the copper. You can only avoid that by having a solution which is sufficiently dense for the amount of current and of proper temperature and sufficient acidity. The circulation is probably one of the most important conditions that determine the accuracy of the voltameter, and that is perhaps the reason why the method to-day described gives better results than the others. Under these circumstances it is possible to deposit copper without depositing hydrogen.

Mr. Weston—I have a word to say in regard to the addition of acid. Some years ago it was customary to use a neutral solution. It was thought more satisfactory, because under those conditions the two electrodes were more uniform. Of late years it has been customary to add a small amount of free acid, and that comes right in line with the remark I made a little while ago with regard to the probable formation of some other compounds of copper. In electro-plating you will invariably find that double salts are used—double sulphate of nickel and ammonia for nickel-plating, or double chloride; in silver it is double cyanide of silver and potassium. It was supposed to be due there to the fact that cyanide of silver is insoluble, but that is not entirely the reason for it. The truth is that the nearer you come to a double salt the freer you seem to be from these secondary compounds or bodies precipitated. I think that is a fixed fact. Sulphate of nickel and sulphate of iron and those metals that are highly electro-positive are very readily decomposed by the current, but if they are not combined with some other salts, after they reach a certain condition the solution will not give any more metal. It will give nothing but sub-salts. I have seen deposits from nickel baths, certainly one-eighth of an inch, which were nothing else but sub-salts, and that condition is not brought about immediately but gradually in the solutions. Now, with the more highly electro-negative metals, such as gold and silver, that does not seem to be so marked. In silver we cannot get any indication of it at all in the nitrate, but the metal there does not go down in a condition that suits the practical plater. The copper voltameter, of course, has a decided advantage when we come to measure heavy currents. In nickel salts, iron salts and zinc salts, when the solution is a solution of a normally pure salt, the metal will go down, but we all know that these normal salts can be converted into salts that give no acid reaction. By the addition of a certain amount of oxide they form basic salts. Oxide of nickel and oxide of zinc and oxide of iron, freshly precipitated, are all soluble in the normal salts. An addition, therefore, of a very minute trace of oxide to the solutions, so as to make them basic in their character, immediately renders the solution incapable of giving satisfactory results. That condition will be brought about, notwithstanding the fact that you start with a normal salt, particularly where the anode is larger than the cathode. In zinc salts, even where the anode and cathode have the same surface, it is usually brought about. Care should be taken in the copper voltameter of obtaining a considerable excess of free acid.

Mr. E. T. Birdsall—I am sure every one who has patience to use the copper voltameter will heartily thank Mr. Ryan if he has made their labors easy. I also think it is possible that this form of the helix of copper wire, if it is as good as the figures appear to indicate, will be a valuable hint to those companies that use electrolytic meters. All electrolytic meters that I know of at present use plates and are somewhat in the form of the old copper voltameter, and although those meters are said to be accurate, yet if they are changed into the form of a helix of copper wire in place of the plates, we shall have perfection perfected.

Professor Nichols—I would like to say that Mr. Ryan's results have been corroborated throughout the year by student after student. We have no more trouble with the copper voltameter since the adoption of this method. Formerly, as I stated, we expected errors of 1, 2, 3 or 4 per cent., according to the capacity of the man, but now we get errors of 1.10, 2.10 and 3.10 per cent. If a student gets to 3.10 per cent. we tell him something is wrong.

COMPARISON OF THE PATENT LAW AND THE PROTECTIVE TARIFF.[1]

BY C. A. BROWN.

An ex-commissioner of patents, in opening an argument in an important patent case before Judge Blodgett, prefaced his speech by saying that he believed in the American system of protection of home industries by means of both the protective tariff and the patent law, thus confusing rights, the foundations of which are entirely distinct. There is only contrast between the protection of the tariff and the protection of inventions by the patent law. If one supposed to be versed in the patent law should have such confused notions, it is not to be wondered at that those having little knowledge of the patent law, and giving little thought to the matter, should be liable to make the same mistake. This impression prevails with those who are particularly interested in patent law, and occasions hesitancy on their part to favor action which might tend in any way to disturb the existing protective tariff. There is a feeling even that it is something like bad faith on the part of the man who has his property largely invested in patents, or who depends upon the patent law to sustain the business in which he is engaged, to assail the protective feature of the tariff in any respect. The fact is, the protective tariff is no more similar to the patent law than it is to any other act of our national legislature.

Patent legislation is based upon a constitutional provision which says "Congress shall have the power to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." Under this provision of the constitution, Congress has passed a series of patent laws commencing with the act of 1790.

With reference to the protective tariff not a word is said in the constitution, and it is only by severely straining its provisions that the protective feature of the tariff could be upheld in the courts.

The theory of the patent law is that the inventor is entitled to the product of his own genius and labor. He could keep the secret of what he has discovered, but in order to encourage him to divulge his inventions and discoveries and in order to foster and stimulate in general the making of such inventions and discoveries, a contract is entered into by which the people collectively agree to give him for a limited time the exclusive right to manufacture, sell and use his invention. The condition is imposed that he make the public thoroughly acquainted with his invention, and that after the time for which he is to have the exclusive use of it the public shall be given the advantage of its unrestricted use. The patent therefore, is nothing but the evidence of a contract between the public and the inventor.

There is nothing in the nature of a contract about the protective tariff. The tariff itself is a tax. The revenues from it go to the government; the so-called "protective" part of the tariff is a tax, the revenues from which go not to the government, but to the favored class which is "protected." The price paid for a patented article like the telephone or the electric light contains a profit to the inventor, but the fact that the patented article is sold at all is evidence that the inventor has accomplished something for the general good and advantage; otherwise he could not induce the public to buy or use his discovery. The inventor has the entire right to place a price on his product which will be prohibitory, and prevent the use of the article, but if he succeeds in introducing whatever is in his control, it is evidence that people are willing to pay the price he asks, and that fact means, of course, that they are securing enough advantage out of the use of such patented article to make it profitable to utilize it.

The point of similarity which impresses those who have not given the subject much thought, is that there is protection to the inventor or manufacturer who has acquired inventions which are protected by patents, just as there is protection to the manufacturer or producer of articles on which there is a protective duty. To be sure there is protection in both cases, so also there is protection to the citizen of one state while traveling through another state. There is protection to an American citizen abroad. There is protection in hundreds of ways which no one will for a moment consider in any way allied to a protective tariff. The constitution of the United States provides that no law shall be passed by any state impairing the obligation of contracts. This is a protection to business interests, but it is not in any respect similar to the protective tariff.

It is not intended here to point out the advantages of our patent system nor to enter into a discussion of the expediency of the protective tariff. It is merely proposed to show the contrast between the protective tariff and the patent system in a brief glance at some of the legal points of difference between the two, and to indicate to the representatives of electric light and telephone interests that they should have no hesitancy in attacking the tariff on copper, for instance, or lead, or any other material which enters largely into their business, on the ground that people who live in glass houses should not throw stones. The patent law, the foundation of which is laid in the constitution and which has been built up by a series of enactments fortified by experience, should not be compared to a house of glass. Those who are interested in the maintenance of the patent law should not shrink from a thorough investigation of its merits and comparison of its principles and its effects with those of the protective tariff.

1. From *Western Electrician*, Chicago, October 26, 1889.

ELECTRICAL CLOUD PHENOMENON.[1]

BY W. K. BURTON.

A short description of a curious cloud appearance observed by me this summer may be of interest to your readers. It was noticed in Kiushu, the southernmost of the three great islands of Japan, early in July, at a distance of 10 or 12 miles from the sea.

The season had been, and was, after the time of the observation, an exceptionally rainy one, severe floods being produced in almost all parts of the country, but it was not raining in the place where I made the observation at that particular time. Time shortly after midday, thermometer about 80 degrees F.

The sky was clear overhead, but there was a great bank of heavy "thunderous" looking clouds to the south. It is most difficult to judge even approximately of the distance of clouds, but these might be from one to two miles off; the lower edge was represented by a very nearly straight line, and there was an amount of blue sky visible under the clouds that would perhaps subtend from 10 degrees to 15 degrees.

My attention was attracted to a sort of "tail" of cloud stretching itself downwards from the straight under-side of the cloud bank. It gradually extended till it reached some two-thirds of the distance from the cloud to the earth. It remained of about constant length for a little over 10 minutes, the lower end continually waving about in a most curious way, giving the impression almost that it was feeling for something.

Quite suddenly the filament of cloud straightened itself out, and extended itself towards the earth. The lower end became so very thin that, from the distance, it was impossible to see whether it actually made contact with the earth or not, but I have not the smallest doubt that it did, and that a silent discharge took place at the time. There was certainly no sound heard. Immediately after the contact the filament rapidly drew itself up to the cloud,

1. From *Nature*, November 7, 1889.

CORRESPONDENCE.

NEW YORK AND VICINITY.

The State Executioner not Called as an Expert in the Feeks Case.—New Electric Companies.—Cheap Aluminium on the Market.—Dying Out of the Overhead Wire Excitement; Activity of the Subway Construction Company; Tearing up of Streets.—The New York Electrical Society; Interesting Meetings.—Another Murderer Sentenced to Death by Electricity.—New Cables Laid by the Western Union Telegraph Company.—Long Island Life-Saving Stations Connected by Telephone Lines.

In the coroner's inquest on the body of Lineman Feeks, Mr. Charles Cuttriss, electrician of the Commercial Cable Co., assisted as an expert on behalf of the coroner in the effort to ascertain the ownership of the wires which caused his death. It is a gratification to the electrical fraternity to know that in this particular case, the services of the State Executioner were not called into requisition on account of a vigorous protest on the part of the electricians who would have thus been compelled to associate with him.

Notwithstanding the apparent sufficiency of electric companies to handle the business in New York, two more have recently made their appearance, the Easton Electric Co., which has taken offices at 45 Broadway, and the Richter Electric Construction Co., which has taken the remaining office on the ground floor of the Telephone Building, 18 Cortlandt street, facing directly on the street.

In the offices of the *Engineering News*, there is exhibited a small bar of aluminium from a Pittsburgh establishment, which is now putting that long-sought for metal on the market at $2 per pound in large quantities. The prospects are that it will be produced at a much lower price at an early date.

The excitement created by the newspapers regarding the overhead wires in the streets of New York has died out, but there has been renewed activity on the part of the Subway Construction Co., which is tearing up the east side of the busiest part of Broadway, below Fulton street. This obstruction to travel combined with an active fall trade led to one of the most serious blockades of Broadway on November 26, which has ever occurred. As under the future condition of affairs there is likely to be still more frequent obstructions of the streets, and the volume of traffic is continually growing, the prospect is not cheerful.

There is a prospect also of having Broadway torn up again for the purpose of constructing a cable railway. The board of aldermen is already making preparations for a junketing tour in order to see how cable railways work in other cities, and also to determine the best kind of a grip, for which mission they are supposed to be particularly well adapted. Electricity has now so firmly established its claims as a suitable power for street railways, that it seems imprudent for any company to make a permanent investment of the sum necessary for a cable equipment, which is extremely likely to become obsolete in a few years. It is stated, however, that the cable companies of San Francisco are dividing about 70 per cent. annually, and, of course, the temptation to use a similar system in this city is very strong.

At the 123d meeting of the New York Electrical Society at Columbia College on the 13th of November, Mr. Francis B. Crocker gave a "talk" on "How to Test Electric Motors." Mr. Crocker, who is one of the joint inventors of the well-known "C. & C." motor handled the subject with entire satisfaction to an interested audience. His remarks were accompanied with practical demonstrations with the Crocker and Wheeler, and the Sprague motors. There are to be a series of "talks" before the society during the winter, among them being, "Progress of Electric Railroads," "A Talk on Cables," "The Electrical Torpedo," "New York's Sole Defense," "Storage Batteries," "The Incandescent Lamp," "The Telegraph," "The Telephone," "The Alternating Current," "The Galvanometer and its Uses," "Electricity in War," "Phantom Wires," "How to Run an Electric Light Station," "Transformers," "Power Transmission," "Laboratory Manipulations," "The Social Side of the Electric Street Railway," "The Solution of Every-day Electrical Problems," and "The Progress of the Year."

It is expected that Chas. McElvaine, of Brooklyn, will be executed by electricity at the Sing Sing prison, where he has been removed. The record of the trial is to be sent to the Court of Appeals before the first day of December, so that it is possible that the appeal may be heard and decided before December 9th, during the week following which date the sentence is appointed to be carried out.

The Western Union Telegraph Co. has followed the example of the Commercial Cable Co., and laid two new cables between Canso, N. S., and the southern beach of Long Island. This enables the company to avail itself of a more reliable route for its European cable connections, and the land lines heretofore used have frequently failed in severe storms. This shows the advance made in cable telegraphy since the first Atlantic cable was laid, when every opportunity was availed of to shorten the cable routes and utilize land lines. The reverse appears now to be in some cases the better policy.

The government life saving stations on Long Island have recently been connected by a telephone line, and it is expected that the efficiency of the society will be considerably increased thereby.

New York, November 27, 1889.

PHILADELPHIA.

Electric Light Wires to go Underground.—The Germantown Electric Light Plant.—Other Electric Light Notes.—Suit for Damages Against an Electric Railway Company.

City Councils Law Committee has again fixed a date for the removal of overhead wires, but this time it has arranged a graduated scale to guide the companies in obeying the law. This schedule is as follows:—

All electric light wires between Vine and South streets and the two rivers must be underground by December 1, 1890; between South street and Washington avenue, Vine street and Girard avenue, and Gray's ferry and Girard avenue, West Philadelphia, by December 1, 1891; and all other parts of the city except the rural sections, by December 1, 1892. To bury the telegraph and telephone wires the companies are given a year's more time in each district than with the electric light wires, so that it will be December 1, 1893, before the wires in the outskirts of the city go underground. There are now in the city 10,324 telegraph, telephone and electric light poles, of which 4,649 are owned by the city and 5,675 by various companies. Up to the present time 825 miles of wire have been placed underground, but over 5,000 still remain overhead.

The matter of the Chilton Avenue Railway was again before the railroad committee of councils recently. The question of motive power had been raised, and the committee decided to hear from President Barr upon that point. Mr. Barr was present, and stated that it was the intention to use horses. The recent railroad act gave them the right to operate by cable or electricity, but they could not use the overhead wire electric system without the consent of councils. The ordinance was reported with a favorable recommendation.

Wm. G. Warden, of the Atlantic Refining Co., with other capitalists, has purchased the Germantown electric light plant, and will erect a large building for lighting purposes at Armat and Cumberland streets. The new company intends to establish an extensive incandescent electric lighting system.

Retail storekeepers along Frankford avenue, above Norris street, have formed a company to provide their own electric lights. They have 25 arc lights in operation.

The new electric light plant at Williamsport, Pa. will use 30 tons of wire.

Jerome Carty, of this city, will shortly appear in the United States Court as counsel for James Anderson, who sues the Electric Street Railway Co., of Newport, R. I., for $15,000 damages, his brother William having died from injuries received in an accident on the road.

Philadelphia, November 19, 1889.

BOSTON.

Output of Telephones.—Motion by the American Bell Telephone Co., in the Government Suit, to Restrict the Testimony to the Question of Fraud.—Suit of Stockholders of the Thomson-Houston Company to Determine the Ownership of Electric Welding Patents.—The Board of Aldermen and Electric Interests.—Dinner of the Boston Electric Club.—A State Electric Light Association Organized.—Accidents at Lynn.—Progress of the Electric Plant of the West End Railway.—Annual Meeting of the West End Railway Co.

The statement of the output of telephones by the American Bell company for the month ending October 20, is as follows:—

October—	1889.	1888.	Increase.
Gross output	5,152	4,140	1,012
Returned	1,781	2,145	*364
Net output	3,371	1,995	Inc. 1,376
Dec. 21 to Oct. 21—			
Gross output	48,394	45,800	2,594
Returned	19,898	18,986	912
Net output	28,496	26,814	Inc. 1,682

* Decrease.

A motion was filed on the 6th of November, by the defendant in the case of the United States *vs.* American Bell Telephone Co., that the following order be passed by the Court.

Ordered. That the testimony be taken by the respective parties under the pleas of the defendants shall be limited to the single issue raised by said pleas, namely, whether the said Bell obtained either of said patents by means of the fraud set up in the bill; and that no testimony shall be taken in reference to any prior inventions set up in the bill, unless upon the further order of the Court.

On the 15th of November a hearing upon this motion was had before Judge Colt. The Court refused the order. The Court has

named three months as the period within which the testimony for the government shall be taken.

On the first of November a suit in equity against the officers of the Thomson-Houston Electric Co. was begun in the State Supreme Court by several stockholders of the company, for the purpose of settling the question of the ownership of the patents in the electric welding process. It is claimed by the plaintiffs that these patents are the property of the Thomson-Houston company, but the directors of the company took a different view when they formed a separate corporation to carry on the electric welding business.

At a meeting of the board of aldermen on the 11th of November, an order was offered to authorize the superintendent of lamps to advertise for proposals for furnishing electric lights in the several sections of the city for a period not exceeding five years. Referred to the committee on lamps. An order was also presented requesting the mayor to petition the legislature at its coming session for the passage of an act authorizing the mayor of the City of Boston to appoint three persons, who shall receive a salary of not less than $3,000 each per year, with power sufficient to superintend the construction, maintenance and operations of the work of all private corporations that occupy a space under any street more than 18 inches beneath the surface; also, that all proper and necessary expenses incurred in the discharge of their duties, and the salaries of the commission, shall be apportioned in an equitable manner and borne by all corporations affected by this order. The order was assigned to the next meeting.

On the 21st of October, the mayor had sent to the aldermen a communication to the board stating that the control of electric wires on the part of the city by means of ordinance is insufficient, the result being that the public is exposed to serious risks and dangers. As immediate action is necessary, the mayor suggests that the fire department be authorized to regulate and control all electric wires through the superintendent of the fire-alarm telegraph. This department, the mayor says, only needs the power to give the people the protection they are entitled to. If the aldermen should pass an ordinance as suggested, the mayor thinks it would be well to place the fire department in charge of all electric wires above or below the street level, present or prospective. The communication was referred to the special committee on electric wires.

The dinner of the Boston Electric Club at the Boston Tavern, November 12, was attended by about 50 members. W. J. Denver presided, and among the guests were Mayor Hart, Fire Commissioners Fitch, Murphy and Tobin, and W. A. Hovey, of the Bell Telephone company. "Municipal Regulations and Control of Electric Wires and Wiring," were discussed by Mayor Hart, Colonel R. N. Ransom, John C. Wilson, Frank Ridlon and others. Messrs. Brophy and Chapman expressed themselves in favor of a board of control. Mr. Hovey opposed the board of control, but admitted the necessity of some regulation not legislative.

Forty-five gentlemen, representing 40 electric lighting companies in all parts of this state, using all forms of apparatus and having a combined capital of $4,000,000 or $5,000,000, met at the Tremont House at noon November 7, and formed the Massachusetts Electric Lighting Association. Hon. T. C. Bates, of Worcester, called the assemblage to order, and E. W. Burdett, the attorney for the Boston Electric Light Co., acted as secretary. Mr. F. A. Gilbert, the president of the Boston Electric Light Co., was elected president of the association, and an executive committee, consisting of the president, ex-officio; Hon. T. C. Bates, of Worcester; George W. Fifield, of Lowell; C. L. Edgar, of Boston, and C. A. Nichols, of Springfield, were chosen to have charge of the affairs of the organization. A set of by-laws were adopted in lieu of a constitution, and they provide that the object of the association shall be to foster and promote the common interest of its members, and that the membership shall be limited to companies engaged in the business of local electric lighting and the supply of electric power for commercial purposes. After the business meeting the assembled gentlemen sat down to an elegant dinner, as guests of the Boston Electric Light Co.

Theodore Driver, an employé at the Thomson-Houston works at Lynn, while putting in wires in a department of the works, October 28, brought his head between two wires each carrying a current of 1,000 volts. He was instantly thrown to the floor, dropping some seven or eight feet. He was picked up in a semi-conscious condition, but revived and was taken to his home on Chase avenue.

On the 11th of November, at Lynn, the trolley wire of the electric street car line broke at one of the joints and fell into the street. Before any warning could be given to passers-by, a horse and buggy driven by Dr. S. Simmons, crossed over the fallen wire. One of the horse's feet touched the wire, and he dropped instantly. The doctor did not feel any shock, and, thinking his horse had fallen in a fit, got out to bleed him. After kicking a while the horse got up, and did not appear to be injured.

The central power station of the West End electric railway will have 13 engines, each of 1,000 h. p., of the Reynolds-Corliss pattern. The engines have been built specially for the work they are to do. The ordinary fly wheel of an engine of this pattern weighs 40 tons; those built for the West End Street Railway, 60 tons. This extra weight will carry the engine for two or three revolutions in case the normal load is suddenly doubled by a short circuit on the line. The tracks on Warren street have been relayed from Grove Hall to Moreland street. This line will probably be started in about a month. The new track on the Pearl street line, Cambridge, is laid, and work is being pushed on the relocation of tracks in Main street, near Columbia street. Arrangements have been made also for connections with the tracks to be laid through Front street, which will cross the new Harvard bridge, leaving Main street at Lafayette square. On Monday night, the 11th of November, from 12 o'clock to 5 in the morning, 12 electric cars were run over the route between Grove Hall and the Tremont House, for trial trips. General manager Monks, director Little, electrician Pearson, and other officials of the West End road, were in attendance. The trial was very satisfactory, and it is said that the cars made the round trip at the rate of nine miles an hour, part of the way being run exactly on horse car schedule time, while on other portions of the route—on Shawmut avenue, for instance—a speed of 18 miles an hour was developed. On the 14th the cars began running regularly at 10-minute intervals. Thirteen cars are now in use. It is now expected that electric cars between Harvard and Park squares, via Charles street, will begin running next Monday. A turnout has been put in on Charles street, near Boylston, where the South Boston cars are to be attached to the electric cars. Extensive preparations have been made in the shape of mammoth snow plows, to keep the snow from the tracks the coming winter. A 40 h. p. plow was tried out of town recently; loads of gravel were dumped upon the track and was swept aside as so much dust. This winter will be the trial of electric cars for Boston, and the results will determine what is to be done in the future.

The annual meeting of the stockholders of the West End Railway Co. was held in the Meionaon at noon on the 14th. The regular business of the meeting was the election of directors for the ensuing year. President Whitney presided, and when the clerks had read the call for the meeting, and the record of the last meeting, a special meeting of the stockholders for the authorization of the petition for an increase of the capital stock, held on July 25, of the current year, he made a few remarks concerning the work of the company during the past year, saying the Harvard, Bowdoin square line, and the other lines to Brighton and Brookline and Arlington were now operated from the stations at Allston. The beginning of service on the electric line to Grove Hall from the Tremont House was referred to, and the statement made that the directors had great confidence in the electric system, and consider it far ahead of any other method of propelling street cars

BOSTON, November 16, 1889.

CHICAGO.

Mr. S. A. Barton's Departure from Chicago; He Presides for the Last Time at the Chicago Electric Club; Farewell Addresses and Presentation.—Mr. B. E. Sunny's Paper on Mr. Edison's "North American Review" Article at the Electric Club.—Mr. F. G. Beach Elected President of the Electric Club, to Succeed Mr. Barton—The Pan-American Delegates in Chicago.—The Pullman Electric Railway.—Contracts Made with the Western Electric, Thomson-Houston and Brush Companies for Extensions of the City Lighting Plant.—The Trouble About the Site of the Power Station will Delay South Side Lighting; More Underground Conduits.—A Comprehensive Electric Railway Scheme for the West Side.—Some Further Chicago Opinion on Mr. Edison's Deliverances as to the Danger of High Tension.—The Proposed Abolition of the Duty on Copper Favored in Electrical Circles.—Personal Mention.—Chicago Transportation Committee for the Next Convention of the National Electric Light Association.—The Mather Company to Furnish a 3,600 Light Plant for the Old Board of Trade Building, now Remodeled.

AT the last meeting of the Chicago Electric Club, in October, the president, S. A. Barton, resigned his office. Mr. Barton, as stated in the Chicago letter of last month, will make his home in Boston hereafter, leaving the active management of the Chicago office of the Thomson-Houston company in the hands of B. E. Sunny. The members of the club had received notices that Mr. Barton would preside for the last time, and many were present at the meeting. Mr. Barton said his reason for leaving Chicago was a desire to return to the home of his boyhood. Addresses expressive of regret at his departure were made by F. W. Parker, W. A. Kreidler, E. A. Sperry, C. H. Wilmerding, W. A. Pearson, F. E. Degenhardt, George Cutter, A. K. Stiles, J. H. Shay, and D. P. Perry. Alex. Kempt read the following resolutions, which were adopted:—

WHEREAS, The Chicago Electric Club has with unfeigned regret received the resignation, as president, of Silas A. Barton, who for two terms has so ably and with so much advantage to the club, filled the highest position within its gift, and,

WHEREAS, During his residence with us, Mr. Barton has by his great ability, by unflagging faith and untiring industry, broadened the field of electrical enter-

prise, stimulated electrical invention and improvement, and vastly strengthened confidence in the great possibilities of the science, and

WHEREAS, This club owes to Mr. Barton, as its president, a strong and solidified membership, and enlarged field of influence and usefulness, and a financial condition that assures its perpetuity;

Resolved, That the Chicago Electric Club, the representative electrical association of the west, bears witness to the lasting impress that the work of Mr. Barton has made upon the electrical industry, and inscribes upon this page its high appreciation of his zeal, devotion and steadfastness, and that his departure we consider a lasting loss to our club, and bespeak for him many years of usefulness, and a full recompense for his faithful service in the New England home to which he returns.

These resolutions had been engraved on a large silver plate which was presented to Mr. Barton on behalf of the club. Subsequently the retiring president invited the members to a lunch, which was served in the club rooms. Mr. Barton has made an enthusiastic executive officer, and the club has prospered marvelously under his management.

The meeting of November 18, was one of the most interesting in the history of the Chicago Electric Club. B. E. Sunny read a paper on "The Use of High Tension Currents in Electric Lighting." It was in the nature of an answer to Mr. Edison's article in the last *North American Review* on "The Dangers of Electric Lighting." Mr. Sunny thought that Mr. Edison's assertion that circuits carrying high potentials could not be made safe, was incorrect, and that his statements were made with a view to increasing the sales of Edison apparatus. The present hue and cry against high tension wires in New York was due, Mr. Sunny asserted, to the deplorable construction work in the metropolis. The conclusions of Mr. Sunny were that Mr. Edison's paper was unjust and unfair for the following reasons :—

First. It pronounces the system that Mr. Edison's company uses safe, and the systems used by his competitors as unsafe.

Second. It characterizes the companies using the high tension currents as "the promoters of electric lighting enterprises which spring into existence with the growth and stability of mushrooms."

Third. It scrupulously avoids any mention of the innumerable safeguards thrown around the so-called dangerous currents to prevent their being dangerous, such as the use of transformers, to change the current from a high to a low pressure at the point where it enters the building; the appliances used at the central station to detect the presence of defects in the wires outside, and the many other devices that central station men are familiar with.

Fourth. It asserts that high pressure wires cannot and ought not be allowed to work underground. There is strong evidence that they can be worked underground successfully and safely. In this connection it may be remarked that it is probably the first time that Mr. Edison has ever said that such a comparatively simple thing as working high pressure wires underground was impossible. The utter hopelessness with which he regards the question is in strange contrast with his well-known habit of including about everything imaginable among the possibilities.

The members of the club discussed the paper at considerable length, and adopted the following resolutions :—

Resolved, That it is the sense of the Chicago Electric Club, that the objections to, and the general condemnation of the high pressure systems of lighting set forth by Mr. Edison in an article in the November number of the *North American Review*, are not sustained, and that the growth and popularity of the service furnished by this class of currents are in themselves a contradiction of Mr. Edison's conclusions, and further be it

Resolved, That with proper construction and exercise of reasonable intelligence, the high pressure currents are absolutely safe.

At the same meeting Mr. Sunny announced that the board of managers had elected F. G. Beach of the Central Union Telephone Co., to the presidency, to fill the vacancy caused by the resignation of S. A. Barton. The managers also made the following appointments :—First vice-president, F. B. Badt; second vice-president, Alexander Kempt; third vice-president, D. P. Perry; fourth vice-president, W. H. McKinlock.

When the Pan-American delegates visited Chicago they were given an excellent opportunity of admiring the beauties of electric lighting. At a banquet given in their honor, incandescent lamps were utilized on an extensive scale for purposes of decoration. Floral pieces representing a steamship, a train of cars and a map of the western hemisphere were brilliantly lighted up by tiny lamps. The ship was particularly effective as an ornament. In each of the port holes a little lamp was gleaming. The delegates were given a chance to test the efficiency of the fire alarm service. While driving about the city a representative from South America was permitted by the mayor to sound a false alarm. The engines and hose cart appeared on the scene almost immediately, greatly to the edification of the visitors.

A number of references have been made in the Chicago letter to the proposed Pullman electric railway. Charles L. Pullman said recently that two miles of track had been built so that the several electric systems might be tested. "We want this road to illustrate" he said "all the conditions which are encountered in the practical operation of street cars. It is our intention to give the several companies an opportunity to exhibit the merits of their respective systems. The road will therefore be more or less experimental until we make a final choice of a system. We propose also to give the companies for whom we are constructing cars a chance to experiment with their motor cars on our road."

Contracts for the extension of the Chicago City Electric Light Plant have been awarded. Five hundred lights will be added. The Western Electric Co. will furnish machines for 200 lights, the Thomson-Houston company for 200 lights, and the Brush company for 100 lights. The power houses and the conduits have been practically completed. As a result of the injunction restraining the city from erecting a power house on the lake front the South Side will not have additional electric lights this year. Conduits were built for wires leading from the point on the lake front where it was intended to build the station. The cost of this construction was about $30,000. The conduit cannot be utilized this year as there is no money in the hands of the city electricians for the purchase of a lot near the lake front. The operation of the high tension wires in the city conduits will be watched with interest. Professor Barrett thinks there will not be the slightest difficulty. He expects to be able to demonstrate that Edison's fears about the dangers of high tension circuits when buried are groundless.

Another electric railway company has been formed in Chicago. It has a capital stock of $1,000,000 and the projectors say they mean business. The corporation is known as the Chicago Electric Railway Co. The company, according to one of the incorporators, has planned an extensive system of electric railways for the West Side, which at the present time is sadly in need of rapid transit. The company has not yet decided upon any system. It is true that they cannot secure an ordinance permitting them to use overhead wires in the city limits. That fact may bother the new company.

The recent deliverances of Mr. Edison on the high tension question have been read with interest everywhere. Persons in Chicago, however, may be found who would scarcely concede everything that Mr. Edison has uttered. In fact they would assert that high tension direct and alternating currents have been distributed in Chicago successfully, and that the record of fatalities is marvelously small. Three or four deaths, at the most, can be attributed to the cause in the history of electric lighting in Chicago. Of these, one death was the result of the carelessness of a workman in an electric light testing room. Another death was caused by the falling of a lamp trimmer from a ladder. Whether a shock caused him to lose his balance or not is a disputed point. During the last two years no one in Chicago has been even seriously injured by a shock from any station circuit carrying either direct or alternating currents. It is, therefore, hardly fair for Mr. Edison to speak of the terrible results which will ensue even if circuits are put underground.

C. A. Brown, chairman of the committee of the National Electric Light Association, appointed to petition Congress to remove the tariff on copper, says :—"So far as I have made inquiries I have not yet found anyone who, on the merits of the question, favored the retention of the tariff on the different forms of copper."

The Thomson-Houston company, of Chicago, has installed a 30-light arc dynamo and a 500-light incandescent machine in Jacob's Clark Street Theatre. Power is provided by a 100 h. p. New York safety engine.

E. J. King, of the Jacksonville (Ill.), Gas Light and Coke Co., who was well known in electric light circles died recently.

John Crerar a prominent Chicago merchant died recently. He was a director of the Chicago Telephone Co.

F. W. Cushing has taken an interest in the Central Electric Co. He will be consulting engineer, and will have charge of the department of construction.

The following transportation committee for Chicago has been appointed by President Weeks, of the National Electric Light Association: C. H. Wilmerding, F. E. Degenhardt, and W. A. Kreidler.

The building which was once occupied by the Chicago Board of Trade has been remodeled, and now towers aloft with its 13 stories. The Mather company has been awarded a contract for installing in the building an electric light plant with a capacity of 3,600 incandescent lamps.

CHICAGO, November 18, 1889.

ST. LOUIS.

The Syndicate Purchase of the United Electric Light and Power Company.—The New Telephone Building.—The St. Louis Heisler Company.—A Competent Superintendent of City Lighting.—Electric Railway Notes.—Electric Lighting Notes.

ON October 28th, the final payment of 50 per cent. of the purchase price for the entire capital stock of the United Electric Light and Power Co., of St. Louis, was made by President McMillan, of the Laclede Gas Light Co., on behalf of the Hollins & Co. syndicate of New York. On the following day W. L. B. G. Allen was elected president, J. D. Thompson secretary and treasurer, and the general office was moved to the Laclede Gas company's building on Washington avenue. Mr. E. J. Bagnall, superintendent of the Brush station, was appointed general superintendent.

exhibition. The power for all these machines was obtained from a number of engines from the Westinghouse Machine Co. Among them was their new rotary engine, which latter created great interest on account of its novelty. This engine is the result of the untiring efforts of Mr. Westinghouse, who has worked for its success during the last five years.

The Allegheny County Light Co. has made the announcement that the board of directors will meet, sometime in January, to increase the capital stock of the company.

Allegheny common councils have at last been able to decide upon the purchase of a site for the power house of the electric light plant which is being furnished to the city by the Westinghouse Electric Co.

Work on the building of the Westinghouse Electric Co., which was destroyed by fire some time ago, is now rapidly progressing, and it is expected to have it completed within 60 days.

The St. Clair electric railway, which is situated on the south side of this city, but has been idle for several months, is about to resume operations. The road has recently undergone extensive improvements, about $60,000 having already been spent, and $15,000 more will be put in. The road is now furnished with Daft's improved system of overhead conductors.

A net-work of electric roads to connect with the new Pittsburgh incline is to be built on Mt. Oliver, and the fare from that part of the south side is to be greatly reduced.

The roads are to be constructed by Philadelphia capitalists interested in the Knoxville Land Improvement Co., who are now building the new incline extending from South Eleventh street to Allentown. Manager Grimes, of the Knoxville Land Co., who is the agent of the Philadelphia syndicate, is now in correspondence with several electrical companies with a view of selecting the most desirable system.

The Electric Railway Construction Co., of this city, is a corporation owning the patents of the McElroy-Nicholson electric street car motor system. Mr. McElroy, the inventor, was formerly connected with the Western Union Telegraph Co., and he was also the manager of the associated press bureau in this city.

For some time the company has been laying a track on Carson street, and made preparations for a test of the system. Over $40,000, it is said, has already been spent in developing the invention. It is expected that the final trial trip will be made some time during December, and the promoters are expecting very satisfactory results.

PITTSBURGH, November 16, 1889.

LITERATURE.

Traité Théorique et Pratique d'Électrochimie. 1er Fascicule. By DONATO TOMASSI, Sc. D. Paris: E. Bernard & Cie.

IT was at the very beginning of the present century, that the epoch making discoveries of Galvani and Volta were made. It was thought at first, that in these discoveries the domains of chemistry had been enriched by the annexation of a new province of research. The explorations made of this "El Dorado" of physical science, by scientific observers and investigators, soon revealed the fact, however, that the new territory was too broad, too extensive, and too rich to remain a tributary province very long. It is precisely this territory that seems yet but an "undiscovered country" of boundless extent, even after having been a field of far reaching explorations and discoveries for a hundred years, that has come to be designated under the comprehensive title of electro-chemistry. For nearly 50 years the term electro-chemistry might have served quite appropriately to include all that we now designate under the broad term of "electrical science." It is in this, the older portion of the realm of electrical science, that were unearthed the treasures of discovery and of knowledge which made or helped to make famous the names of Davy, Smee, Grove, Daniell, Spencer, Jacobi, Faraday, Becquerel, de la Rive, Schoenbeim, Weber, Grotthüss, and hosts of others, including, later, names like Thomson, du Moncel, the late Gaston Planté, d'Arsonval, Gore, etc. This branch of our science has propounded many important problems to the investigator; but on the other hand it has solved many problems in art, to the benefit and advancement of civilization. The arts of electroplating, electrotyping and electro-reproduction, only need to be mentioned by name to remind us of their wide usefulness and importance. The arts of electrolytic refining, electro-metallurgy and the applications in tanning and bleaching, treatment of sewage, etc., though much younger, bid fair to rank with them in magnitude of results. The electrical storage of energy is the last, and in many respects possibly the greatest of its triumphs; and the possibilities which electro-chemistry suggests in this branch alone are sufficient to command the admiration and interest of all who are engaged in the development of our sciences, theoretically or practically.

The book under notice represents one of the first attempts made thus far, to bring together from all quarters and sources the material, consisting of facts and principles, necessary for a logical and comprehensive exposition of electro-chemistry, theoretical and practical. It is difficult to estimate, from the first part alone, what the extent and scope of the work will be. Moreover, the author has for some reason, omitted a preface, and has failed to give, even by way of introduction, any clew to the method which is to be followed in handling the subject. A table of contents is also absent, being presumably intended to supplement the last section or volume when that shall be published. The impression gathered from a perusal of the first volume of Dr. Tomassi's work is favorable in some regards, and leads the reader to anticipate a quite exhaustive work on electro-chemistry, if the author carry out the rest of the work in the same elaborate way. At the same time, we have somehow gathered the notion, that the term "treatise" is not quite so appropriate as would be "encyclopedia," or "compendium." This portion of the work is, in brief, essentially a compilation from various sources, of the facts, data, and principles related to electro-chemistry,—an exceedingly valuable one, it is true, but yet a compilation as distinguished from a treatise or hand-book of the subject. The author seems to have spared no pains to ransack the literature of the subject, to get his material, and he has not, usually, stopped short of the original sources, giving due credit to the investigator, and the date at which the knowledge was first made public. Possibly the best way to express it is that the work falls short of being a treatise, not so much owing to lack of quantity or quality of material, as to an apparent lack of order or method in connecting the different links of the subject so as to form a continuous chain of exposition. In many cases, the observations of others are, so to speak, merely transcribed without comment or analysis by the author, and this reduces their value to the student.

The work begins with a paragraph on "the identity of statical and voltaic currents," in so far as electro-chemical effects are concerned, and quotes from Faraday in regard to the relative quantitative effects produced by each. It strikes us that a brief statement of the nature of electrolysis, either with or without historical references, would have formed a more appropriate beginning. The author then follows with a few pages on the "Units of measurements," and then gives the definitions of the words most frequently used, omitting, however, several words or phrases, such as "deposit," "specific resistance," "polarization," that ought to be included in such a work. There is a passing reference to the conditions of maximum output of batteries and dynamos, and then follow some details on the voltameter. The silver deposition voltameter, so much used in physical investigations, is not even mentioned. Further on we find the "laws" of electrolytic action stated, but scarcely in right order or in proper language. The laws of Faraday, Joule, Sprague, might be accepted, but the "laws" of Volta and Ritchie, would, in our opinion, require some modification of statement to say the least, to be acceptable, in the present state of knowledge. The latter of these is certainly in apparent contradiction with the law that follows next, that of Joule, which is universally accepted. The next 20 pages contain allusions to different conditions, and their influence, such as temperature, current density, etc., and of certain peculiar effects observed, under various conditions, such as secondary electrolysis, polarization, etc. The second section, of some 30 pages, deals with the phenomena of electrolytic transfer, and with certain actions studied by physicists, such as osmosis, endosmosis, etc. The third section treats of the chemical effects taking place in the presence of electricity. Section iv. refers to the preparation and the chemical and electro-chemical properties of the various elementary bodies. This covers some 120 pages, and is undoubtedly the most valuable part of the volume. It contains a number of very valuable tables, some of which are not usually to be found outside of physical works, notably Mendeleyeff's classification of the elements according to the periodic law, the scale of hardness, relation of specific weights to hardness, tensile strength, ductility and compressibility, etc., etc. Each element, beginning with hydrogen, is then considered separately, and its properties carefully detailed and tabulated. The author gives many data that are of the highest value, and usually quite difficult of access. For hydrogen, as an instance, he gives not alone the atomic weight, chemical and electrolytic valency, but the density, point of liquefaction, index of refraction, thermic value, specific heat (at both constant volume and constant pressure), atomic heat when occluded in palladium, temperature of combustion in air, and in oxygen. He has also added a table giving the amount of hydrogen occluded in various metals. The different states or conditions under which the element occurs in various reactions are also considered fully, and authoritatively, the references being indicated by name as well as by date. In the case of the metals, their electrolytic preparation or their electro-deposition is somewhat fully considered. But the details and references are of greater value to the physicist than to the practitioner, however. This is particularly true in the case of aluminium. There are no less than 12 processes or methods given of electrolytically preparing this metal. Of these, we are doubtful if more than one have the least practical merit or value; in fact, we doubt, as have many authorities, such as John T. Sprague, before us, whether any aluminium was ever in reality obtained by these methods.

The formation of this salt is expressed by the following equation :—

$$Pb_3O_4 + 2SO_4H_2 = S_2Pb_3O_{10} + 2OH_2.$$

Minium. Sulphuric acid. Red lead salt. Water.

These, then, are the salts which constitute the original active material of storage cells when that material is formed by the admixture of sulphuric acid with litharge or minium respectively, and it is highly probable that one or the other of these salts takes part in the electrolytic processes of the storage battery. It is fortunate that these hitherto unknown salts (and not the ordinary known sulphate) are formed in the cell reactions ; for, in the alternative case, lead storage batteries would be practically valueless.

If the buff lead salt be the active material of the battery plates, then the following equations express the electrolytic reactions taking place in the cell :—

I. In charging—

(*a*) *Positive Plates.*

$$S_2Pb_5O_{14} + 3OH_2 + O_5 = 5PbO_2 + 3SO_4H_2.$$

Buff lead salt. Water. Lead peroxide.* Sulphuric acid.

(*b*) *Negative Plates.*

$$S_2Pb_5O_{14} + 5H_2 \quad 5Pb + 3SO_4H_2 + {}_2OH_2.$$

II. In discharging—

(*a*) *Positive Plates.*

$$5PbO_2 + 3SO_4H_2 + 5H_2 = S_2Pb_5O_{14} + 8OH_2.$$

(*b*) *Negative Plates.*

$$5Pb + 3SO_4H_2 + O_5 = S_2Pb_5O_{14} + 3OH_2.$$

If the red lead salt be the active material, then the following equations express the same electrolytic reactions:—

I. In charging—

(*a*) *Positive Plates.*

$$S_2Pb_3O_{10} + O_2 + 2OH_2 = 3PbO_2 + 2SO_4H_2.$$

Red lead salt. Lead peroxide. Sulphuric acid.

(*b*) *Negative Plates.*

$$S_2Pb_3O_{10} + 4H_2O = 3Pb + 2SO_4H_2 + 2OH_2.$$

II. In discharging—

(*a*) *Positive Plates.*

$$3PbO_2 + 2SO_4H_2 + 2H_2 = S_2Pb_3O_{10} + 4OH_2.$$

(*b*) *Negative Plates.*

$$3Pb + 2SO_4H_2 + 2O_2 = S_2Pb_3O_{10} + 2OH_2.$$

An inspection of these equations discloses, in the case of the red lead salt, a fact which has already been roughly observed in practice, viz., that only half as much active material is electrolytically decomposed on the negative as on the positive plates ; whence it follows that the weight of active material on the negative plates need not exceed one-half of that upon the positive plates ; for, in the decomposition of the electrolyte, equivalent quantities of oxygen and hydrogen are evolved—that is to say, two atoms of hydrogen for each atom of oxygen. But in the decomposition of the red lead salt four times as many atoms of hydrogen are required to reduce the salt to metallic lead as atoms of oxygen which are necessary to transform the lead of the salt into peroxide. When, however, the active material of the positive plate has once been converted into peroxide of lead, it seems probable that the red salt only is formed ; at all events, until the discharge at high potential is nearly completed, when there are indications of the production of the buff-colored salt. But this is a point requiring further investigation.

I have to thank Dr. F. R. Japp, F.R.S., for his assistance in the analytical work of this investigation.

.... THE advance in dynamo design consists chiefly in the elimination of flimsiness.—*Industries.*

* Mr. Fitzgerald considers that this peroxide is hydrated.

NEWS AND NOTES.

THE PARIS ELECTRICAL CONGRESS.[1]

(Concluded from page 454.)

The first business in the industrial section of the congress on Tuesday was the discussion of M. Crova's paper, read the previous day. It was opened by the author himself, who gave some further particulars of his photometer, especially as regards its constructive details. Any ordinary photometer may be used, the only addition required being a slide in front of the eye piece. This slide contains two apertures—one fitted with a red glass (oxide of copper glass), and the other with a double glass screen, the liquid (chloride of nickel and perchloride of iron) being contained between the two glasses, and about 5 mm. in thickness. An observation is first made through the liquid screen, and then through the red glass screen, the ratio of the two giving the percentage of red light as compared with the carcel. As the light of the carcel is rather of a reddish tint, M. Crova suggested that 0.9 instead of 1 might be adopted for the determination of the "normal voltage" of glow lamps, if a specially white light is desired.

M. de l'Epinay thought that the tint of a lamp could be expressed by an algebraical formula. Let J represent the total light intensity, R the intensity of the red and G that of the green light, then the tint of any source of light can be defined by the formula $J = Ra + Gb$, when a and b are two constants, which must be determined once for all by spectroscopic photometry.

The President, M. Potier, suggested that the meeting should define the "standard candle." At present each manufacturer of glow lamps had his own standard, and the different standards appeared to vary by about 20 per cent. M. Crova thereupon suggested that 0.108 of the carcel should be taken as the correct measure of the standard candle ; but no definite conclusion was arrived at by the meeting.

The next paper read was by Professor Silvanus Thompson, on "Continuous Current Transformers."

After referring to the first apparatus of this kind, which was made by M. Gramme in 1874, the author remarked that the idea had been neglected till a recent date; electricians devoting their attention almost exclusively to the alternate current transformer, an apparatus the theory of which was now perfectly well understood. According to this theory, the ohmic resistance of the secondary circuit was, when the apparatus was at work, augmented by a fictitious value which was proportional to the resistance of the primary circuit; and the author's present paper was an investigation to determine whether a similar relation exists in rotary or constant current transformers. Let E_0, E_1, E_2 and E_3 respectively represent the electromotive forces available in the primary supply circuit, induced in the primary armature circuit, induced in the secondary armature circuit, and given to the secondary or lighting circuit. Further, let N denote the total magnetic flux through the armature, which, in a well constructed transformer, is the same for both circuits ; R_1 and R_2 the resistance of primary and secondary circuits ; i_1 and i_2 the primary and secondary current ; and C_1 and C_2 the number of active wires in the two circuits. Then the following equations obtain:—

$$E_0 = E_1 + R_1\, i_1$$
$$E_1 = v\ C_1\ N\,10^{-8}$$
$$E_2 = v\ C_2\ N\,10^{-8}$$
$$E_3 = E_2 - R_2\, i_2$$

v being the speed in revolutions per second. On the supposition that the losses arising from mechanical friction, windage, hysteresis, and eddy currents are negligible, there must be equality between the energy given to the primary and recovered from the secondary circuit, so that

$$E_2\, i_2 = E_1\, i_1 \text{ and } \frac{C_2}{C_1} = \frac{i_1}{i_2}.$$

By combining the above equations, the author finds that the electromotive force in the secondary circuit is expressed by the equation

$$E_3 = E_0\,\frac{C_2}{C_1} - \left\{ R_2 + R_1 \left(\frac{C_2}{C_1}\right)^2 \right\} i_2.$$

It will be seen that the second term on the right contains a value proportional to the resistance of the primary circuit, or in other words, that the resistance of the secondary circuit appears to be augmented by a certain fictitious amount depending on the resistance of the primary, analogous to the equation of the alternate current transformer. If the losses are not negligible, the resistance R_1 must be multiplied by the term $(1 + P/E_2\, i_2)$, in which P represents the energy lost. The author next referred to the great advantages of the rotary transformer, due to the absence of all external strains, and perfect balance between the

1. From *Industries*, August 30th and September 6th, 1888.

been used as veritable storage reservoirs. The E. P. S. Co. had in fact established a central station at Chelsea, in which batteries were so used. It had been found possible to employ low voltage distribution throughout areas of about 200 yards radius, and at Chelsea the district was served from four battery sub-stations A, B, C, D. Station A was close to the generating station, which had been laid out on a scale sufficiently large to serve eventually 13 sub-stations. The sub-station A was close to the generating station, whilst the distances were, between A and B, 550 meters, between B and C, 500 meters, and between B and D, 450 meters. At each station there were two batteries, one being charged, whilst the other was completely disconnected from the charging mains, and was used for supplying the street mains. The total battery capacity was 2,000 30-watt lamps, but by the addition of motor generators this could be increased by 50 per cent. The author then described Mr. King's automatic devices for changing the batteries and regulating the E. M. F.; but as these are already known to English readers, we need not dwell upon them in this place. The experience of the last five months, during which the Chelsea station has been working, has shown that the expenditure of coal per board of trade unit delivered to the customer varies between 11 pounds and 15½ pounds.

M. POLLAK suggested in his paper a new method of defining the principal properties of storage batteries. Instead of giving merely the capacity of a cell when it leaves the maker, as now, he proposed that the maker should state the capacity when new and after a certain number of years, and the total number of coulombs which a cell may store and give out during its lifetime. The maker should also state the E. M. F. below which the cell should not be discharged. These propositions were not accepted by the congress, and the discussion, as was frequently the case at these meetings, turned upon a question not suggested in the paper. It was the question which of the plates should be called positive, and which negative. Some suggested the adoption of the terms anode and cathode, others red plate and white plate, peroxidized and metallic plate, etc.; but as no proposal received anything like unanimous support, the matter was left undecided, and we shall have to speak of positive and negative plates as before.

In the first section of the congress, dealing with units and measurements, a paper was read by M. WUILLEMNIER on a new determination of the ohm the author had made by the electro-dynamometric method due to M. Lippmann. The conductor used in these experiments was a german-silver ribbon, 34.72 cm. long and 1 cm. by 3 mm. in section. Its resistance in C. G. S. units was found to be 0.301889×10^9. When measured by the aid of these standard ohms connected in parallel, its resistance was determined as 0.302650 ohms. The true ohm was found from these figures to be represented by a column of mercury 1 sq. mm. in section and 106.27 cm. long. Mr. PREECE proposed to define the unit of energy of the watt as that energy which is expended in a conductor by the current of 1 ampere flowing under a potential difference of 1 volt. He further proposed that the unit of illumination, the lux, should be defined as the illumination produced by the carcel at 1 m. distance. This corresponded very nearly to the illumination produced by the English standard candle at a distance of 1 foot.

At the meeting of the industrial or second section, on Thursday, the first paper was by M. ARNOUX, on dynamos. The variables by which the working condition of a dynamo can be expressed are torque, speed, current, and induced E. M. F. Three of these are, however, sufficient for the purpose, and as the induced E. M. F. cannot be directly determined, the author adopted the torque, speed and current as the determining elements. The relation between these variables can be represented by a surface which is experimentally obtained by determining the law between torque and current at different speeds. It was generally supposed that the induced E. M. F. was proportional to the speed, but this was not the case, as proved by the following table, which contains the results obtained with a series Gramme machine tested at 950 and 1,440 revolutions per minute.

Current in amperes..	5	10	15	20
$\frac{\text{e. m. f.}}{950}$	0.0474	0.0737	0.0810	0.0832
$\frac{\text{e. m. f.}}{1440}$	0.0500	0.0743	0.0882	0.0895
Current in amperes..	25	30	35	40
$\frac{\text{e. m. f.}}{950}$	0.0832	0.0832	0.0800	0.0779
$\frac{\text{e. m. f.}}{1440}$	0.0889	0.0882	0.0868	0.0854

At the close of his paper, which was highly theoretical, and contained no practical data, the author suggested that the commercial merit of a dynamo may be expressed by the term

$$\frac{P\,\mu}{W\,n\,X}$$

in which P is the output, μ the efficiency, W the weight, n the speed, and X the price.

The next paper read was by M. LAFFARGUE, on "Distributing Mains," in which the author reviewed the various arrangements for low tension distribution proposed or adopted. He had worked out the mains required for distributing 800 amperes at 100 volts throughout a street 300 m. long, the generating station being 60m. from one end. A loss of 10 volts was allowed in all cases. The ordinary parallel main of equal section required 2,088 kilog. of copper on the two-wire, and 700 kilog. on the three-wire system. The conical main required respectively 3,132 and 962 kilog.; the main of equal section with returning loop required 2,192 and 762 kilog., and parallel mains with five feeders required 1,325 and 556 kilog.

Next followed an interesting communication by M. TURETTINI, on a new method of utilizing storage batteries, which was suggested by the author's hydraulic power installation at Geneva. In this town the Rhone is employed to drive turbines which work hydraulic pumps, the water being stored in a reservoir, the bottom of which is 125m. above the level of the mains from which hydraulic power is supplied to various consumers. The main leading to the reservoir is 6 kilom. long, and the loss of head is from 6m. to 7m. The depth of water in the reservoir is 7m., so that during the day, even when the reservoir was full, the pressure available at the motors was only equivalent to a static head of 125m.; whilst at night, when most of the water passed up into the reservoir, the pressure rose to 138m. The author then inserted into the main where it begins to rise a centrifugal pump driven by a turbine of 120 h. p., the water for the turbine being taken from the rising main. This pump increases the available pressure throughout the town to 135m., and is during the night automatically put out of action, so that consumers have throughout the 24 hours an almost constant pressure at their disposal. In a similar manner the author proposes to equalize the pressure available from a storage battery. If the distribution is to be made at 100 volts, he employs 48 cells, and inserts into the lighting circuit a motor generator, the primary circuit of which is coupled parallel with the battery, and receives power from it. In this manner the six or seven extra cells, which would otherwise be required for regulating purposes, are saved, and a constant pressure maintained.

The two remaining papers read on Thursday in section ii. were both by M. JACQUIN. One was a description of the method about to be employed in the municipal central station of the Halles for the measurement of the insulation resistance of the various circuits, and the other dealt with the energy lost in the outer covering of single cables when used for alternating currents. The apparatus to be employed at the Halles consists of a board with three switches, a voltmeter, and a galvanometer of special construction. One of the switches serves to join the galvanometer with any circuit, the other is for the earth connection, and the third for the voltmeter. One of the machines serving to excite the alternators is used instead of a battery, and sends a current through the galvanometer if there is a leak in the main joined to it at the time. The galvanometer is of the d'Arsonval pattern, arranged in a wooden box, and provided with an ocular, by means of which the deflection can be read off on a transparent scale. The instrument is calibrated by comparison with known resistances, and will indicate a fault of a resistance up to 100 megohms. When planning the installation at the Halles, the engineers had at first intended to use only concentric cables for the high pressure alternate current distribution; but the high price of these cables, the increased insulation required as compared with single cables, and the greater difficulty of making joints and branch connections, caused them to turn their attention to single cables. The concentric cable cost 34fr., and the single cable of equal section 8fr. 35c. per meter run; so that the latter represented a considerable economy. It was, however, doubtful whether single cables were admissible for alternate current distribution, since a certain amount of energy must be lost in the lead sheathing and iron wire armor. To determine this loss, the author, assisted by M. Henry Menier, made a series of experiments at the cable works of Messrs. Menier, in Paris. The arrangement was as follows: A certain length of cable was laid down, and the ends joined with either a dynamo or an alternator, the latter having a frequency of 50. An ammeter and a watt-meter were placed in circuit, and the loss by ohmic resistance determined with a continuous current. The cable was then switched on to the alternator, and the total loss of energy determined by the watt-meter, the current being kept the same as in the previous experiment. The difference in the energy lost in the first and second case gave the loss due to the metallic envelope. The first trial was made with a cable having no metallic envelope, and the same loss of energy was found with a direct and an alternating current. With a lead covered cable the increase of loss with an alternating current was only 2 per cent.; with a cable covered by lead, jute, and an iron armor consisting of spiral wires, the loss was 18 per cent. of the ohmic loss, and if the armor was connected at both ends to the lead covering, this loss increased to 35 per cent. These figures showed that the loss due to the armor is not nearly so great as was commonly supposed, and it was therefore determined to use, for the greater part, only single

The positive plate of a storage battery is that which is connected with the positive pole of the dynamo during the charge, and which forms the positive pole of the cell during the discharge.

The congress recommends M. Crova's method for the photometry of electric lamps.

The metallic return to be adopted in all urban and inter-urban telephone circuits.

After the adoption of these resolutions the president, M. MASCART, read an address, in which he reviewed the labors of this and the previous congresses, and the practical development of the electrical industries. He also announced that the next Electrical Congress would take place in 1892, in connection with the United States International Exhibition. Sir WILLIAM THOMSON then proposed a vote of thanks to M. Mascart, and the proceedings terminated.—*Industries.*

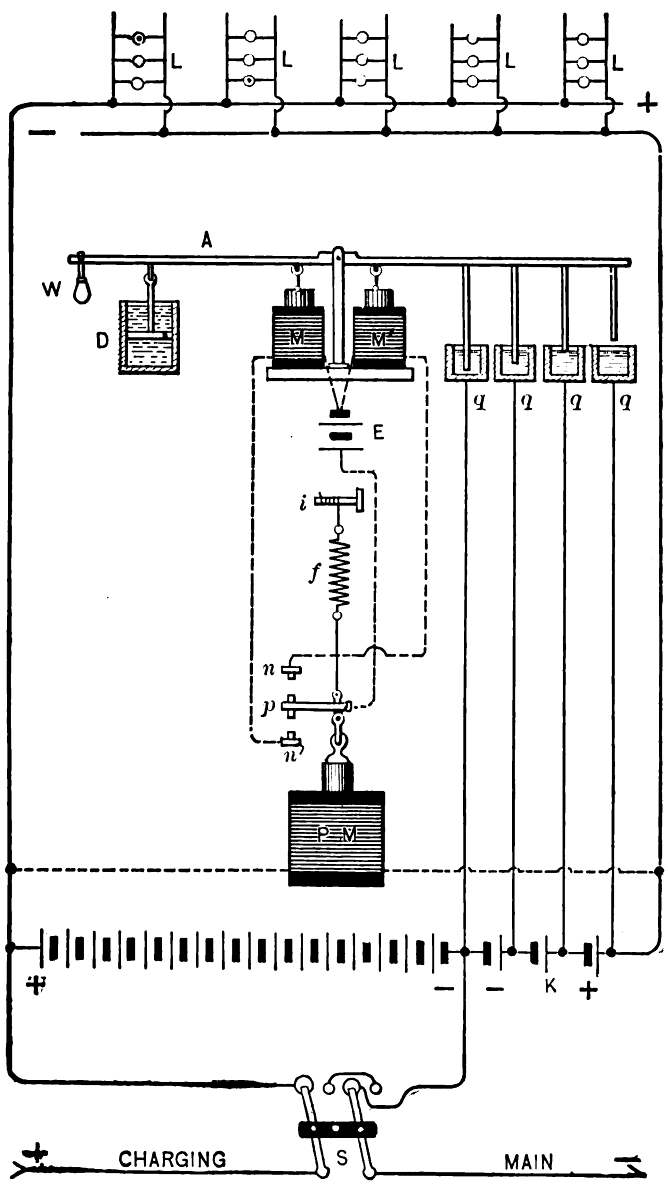
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF OCTOBER 29, 1889.

Mr. George B. Prescott, Jr., read a paper on "Some Methods of Regulating Accumulators in Electric Lighting." (See ELECTRICAL ENGINEER for November, page 464.)

After reading the paper, Mr. Prescott, in continuation, said :—

There is another method of automatically maintaining a constant potential at the lamp mains, which, for special reasons, I had not intended to allude to. It is so interesting, however, that I will make a sketch of it on the blackboard.



In this diagram the lamp circuits, L, are shown at the top, leading from the mains (+) and (−). Connected across the lamp mains, preferably at a point of average potential, is the solenoid magnet, P M, which is wound with fine wire. The position of the plunger or armature of this magnet is so adjusted, by means of the retractile spring, *f*, that when the average pressure is normal, the contact lever, *p*, carried by the plunger, is midway between the local contact points, *n n'*. Probably most of my hearers are familiar with the Kohlrausch voltmeter, which is constructed on this principle of the solenoid magnet, and are aware that, while it is not an entirely reliable instrument on account of variable friction, it still has a wide range and is very sensitive when the plunger occupies a given position. Now this magnet, P M, is based on this fact, and only needs to be accurate for one position of its core or plunger. If, for example, the magnet is wound with wire suitable for a potential of 100 volts, then when it is connected with two points in the lamp circuit, having a difference of potential of 100 volts, the core will occupy a certain position. If the pressure exceeds 100 volts, the core will be drawn into the magnet. If the pressure falls below 100 volts, the core will be withdrawn by the retractile spring. This core of the pressure magnet is suspended from the adjustable shaft, *i*, on the spring, *f*, and carries the local contact arm, *p*, on its upper end. When the core is drawn into the magnet this is brought into contact with the screw, *n'*, and when it is drawn out by the spring, contact is made with the screw, *n*. So long as the pressure remains normal, the contact arm remains midway between the screws, *n*, *n'*, for which position the primary adjustment must be made. If, now, the pressure becomes either excessive or below normal, the circuit of the local battery, E, will be closed, respectively, through one or the other of the local solenoid magnets, M, M'. The cores of these local magnets are attached to a balanced lever, A, at equal distances from and on opposite sides of its point of suspension, and the whole constitutes a simple modification of the regulator, shown in figures 14 and 15 of the paper. The necessary weight of the lever on the side carrying the contact rods which dip into the mercury cups, *q*, *q*, etc., is compensated for by extending the lever for an equal distance on the opposite side of its fulcrum, and by adding a suitable counter weight, W.

The operation of this apparatus requires that the lever should remain quiescent in whatever position it may be drawn by the action of either magnet M, or magnet M'; and that, moreover, any movement of the lever at all tending to make or break contact with the mercury cups should be very gradual. Both of these results are accomplished by introducing a slight friction at the point of suspension of the lever, and by adding a carefully adjusted dash-pot, D, in the manner shown in the sketch. Thus, while the slight friction alluded to causes the lever to remain at whatever angle it may be placed, the dash-pot prevents the lever from moving, except very slowly, to whatever position the action of either magnet may tend to set it.

The function for which this regulator is employed is precisely the same as that performed by the somewhat similar regulator shown in figures 14 and 15, viz.: to insert in and withdraw from the main lamp circuit more or less counter electromotive cells, K, according as the pressure at the lamp terminals exceeds or falls short of the normal. The regulator acts in the following manner:—Assuming the potential to be normal, the local contact lever, *p*, will stand midway between the contact points, *n*, *n'*, and the regulator lever, A, will be horizontal, as shown in the diagram. Now, if the potential at the lamp increases, the core of the pressure magnet, P, M, will be drawn down until it closes the local circuit through *n'* and M, and this latter magnet will slowly tilt the lever, P, towards its side, and thus cause first one, and then the other, of the counter electromotive force cells to be inserted in the lamp main, thereby reducing its potential. When a sufficient number of cells have been inserted in the lamp circuit, in this manner, to reduce the pressure again to normal, the core of the pressure magnet again resumes its normal position, breaking the local contact at *n'*, while the lever, P, continues to remain in its new position. If, from any cause, the pressure at the lamps now falls below normal, the attractive power of the solenoid, P, M, will become correspondingly reduced, and the retractile spring, *f*, will draw up the core until the contact lever, *p*, closes through the point, *n*, the local battery circuit through the magnet, *m'*. This causes the lever to be gradually tilted in the opposite direction from before, and therefore, to cut out of circuit one or more counter electromotive force cells until the normal pressure at the lamps is again restored.

It will be seen that this regulator thus automatically maintains a constant pressure at the lamp terminals, irrespective of the fact whether variations of this pressure are caused by the charging current or by the resistance of the lamp leads when the lamp load is altered.

DISCUSSION.

Mr. Townsend Wolcott—Mr. Prescott seems to place a great deal of reliance upon the voltage of the battery as an indication of the amount of charge left in it. If a battery is discharged in just a given manner, as far as my experience goes, the voltage will be determinate, but the higher the rate of discharge the sooner a low voltage is reached, and it is possible, just for experimental purposes, to discharge a battery at so low a rate as never to reach 1 8/10 volts, or even to go below, say 1 9/10. In fact, I think by very slow discharge you could keep it above 1 9/10 and still discharge it clear down so as to spoil it. I suppose in

and that is by the use of a very old form of photometer known as the Rumford or shadow photometer. Let any one take two lamps made with the very greatest care by the methods of to-day, of the same type and marked to give 16 or 20 or whatever candle-power it may be, at the same voltage. Set those up so that the light from them will shine upon a sheet of white paper, and you need to interpose a block so as to get partial shadow, there being one portion in complete shadow and two portions in partial shadow. An inspection will show that one of those shadows is always a shade bluer than the other. Now, this method, I presume, many of you have used. I have used it with much satisfaction in attempting to get two lamps as nearly alike as possible. This method gives a delicate means of getting relative differences of temperature or at least of determining when two lamps are of precisely the same temperature, so that while we are not in position to express that temperature, we are in position to determine equality of temperature with a considerable degree of accuracy.

It seems to me that Mr. Reed's formula, which enables one to calculate, as it does evidently with great readiness, just what the dimensions of a lamp should be, will be of great value.

Mr. Geo. B. Prescott, Jr.—Among the points that I understood Mr. Reed to make, was this—that one of the advantages of a filament of circular cross-section over any other form was that the current density would be less, and to illustrate this I understood him to select a number of carbons of all sorts of cross-section, at the same temperature, or rather at the same difference of potential, and the same current flowing, showing that the resistance was the same. Now, if they were of the same resistance and the same length, the cross-sections must have been equal, and I should suppose that the current density would be the same in all events.

Mr. Reed—They are not the same length. I have stated that the pressure and resistance were the same—the same current at the same pressure. Now, they have different areas of cross-section and different lengths which you will find to be true by inspecting this formula. Of course, if the lengths were the same, the formula could not be true. The length bears a certain relation to the other constants.

The Chairman—As you will have noted, Mr. Reed, in his paper mentioned the fact that the paper itself was called out by a statement made before the Institute in 1886. When Mr. Reed first brought this to my attention it seemed to me that we were not at all wishful to make the publications of the Institute a vehicle for any kind of errors or heresies or heterodoxies, and it therefore seemed well that he should bring his paper before us on that subject, so that it might be cleared up. I think Mr. Reed has certainly rendered us a service in giving us so admirable a paper in so brief and succinct a form.

There being no further discussion we will proceed to the next paper upon the programme—that by another member who is well known to you, Mr. Delany.

Mr. P. B. Delany read his paper on "Telegraph Line Adjustment." (See page 515.)

DISCUSSION.

The Chairman—Mr. Delany said: "Let us assume that it is a fine night." The operators between New York and Philadelphia this evening would no doubt be glad to assume those conditions, and in default of them I have not the least doubt that not only they, but the operators on the long railway lines would be very glad to have placed at their command so valuable an assistance as this which Mr. Delany has brought before us this evening. It is so long since the telegraph was introduced that many of us are apt to assume that it is perfect. There is probably hardly any electrical invention to-day which is so imperfect as the telegraph, and we have reason to be thankful to such men as Mr. Delany for devoting their attention and talent to perfecting it. It is important in connection with such a body as the electrical engineers that we should impress upon our own constituency as well as the public how large and varied is our field, and I think it could hardly have been done in a more emphatic manner than we have had it done this evening, with Mr. Reed, on the one hand, discussing incandescent lamps, and Mr. Delany, on the other, showing how important it is that the traveling public should have a complete telegraph system. When Mr. Delany promised to give us this paper, it occurred to me that it would be well if he would also favor us with some remarks on the gravity cell to which he has been devoting some attention. One merit of Mr. Delany's work, in connection with primary batteries is that he does not claim to light the universe with it. What its demerits are I will now leave him to tell you.

Mr. Delany then read his note on "A New Gravity Cell." (See page 517.)

DISCUSSION.

Mr. Delany (in reply to a question as to the resistance of the cell)—I have not had accurate measurements of it; but from measurements communicated to me by people who had tried the battery, I conclude that the resistance is about the same as in the ordinary gravity cell. One would suppose that the resistance would be increased by the paper box and the paper envelope, but you will note in this battery that the copper electrode is considerably nearer the zinc, and that probably compensates for the intervention of the envelope and the box.

Mr. R. W. Pope—I would like to emphasize Mr. Delany's remarks about the condition of the way lines in this country. Many have an idea that there has been progress in telegraphy as well as other branches, but as to way lines, I can state from recent experience that they are in many cases as bad or worse than they were twenty years ago. I have learned, through inquiries, that the same care is not taken in keeping up the lines as was formerly the case. The matter of adjustment at way stations comes home to every one, for all of us have occasion once in a while to send telegrams to small stations, and very often there are annoying delays that are accounted for by companies on the plea of bad weather. That is taken as something that cannot be prevented—an "act of God." But here is a device for preventing a large proportion of such trouble, and which, to my own knowledge, has been in practical operation for some time; I have recommended it to some of the railway telegraph superintendents, who have since tried it, and have talked with them about it and found that it is giving perfect satisfaction. In fact, at the meeting of railway telegraph superintendents in Washington, one of the gentlemen from Boston said that a storm came up that week and his despatcher told him that they could not have used the wire at all if it had not been equipped with this device.

I knew of a case, last summer, where a freight train was laid out for an hour simply because the office where it lay could not get instructions for the train to proceed. It was a bad night, and it is fair to assume that, if a system of this kind had been in use, they would have had no difficulty; that is, providing the despatcher's office is manned with the proper force to take care of all the wires. That, I am free to confess, is not always the case.

Professor Alfred G. Compton—A question occurs to me—not as an expert at all, but simply as a layman—and I should like to ask Mr. Delany about it. The difficulties along the line occasioned by storms are, of course, increased by the bad condition of the line. I wonder whether putting this adjuster into the hands of the operators may not lead to continued neglect in the care of the lines, and if so, whether by and by we might not reach a condition in which, even with the adjuster, we might be unable in bad weather to operate at all. I don't know what the minimum of leakage or demoralization on the line might be under which the adjuster itself might become unmanageable. I should like to hear a word on that.

Mr. Delany—From experience on railroads in the past, I don't know but it may come about that Professor Compton's fears may be justified, but I trust that that objection will not be raised against the introduction of the system. As regards the amount of escape which would entirely prevent communication, that would be hard to determine. It would depend on the length of the circuit and the character and number of the magnets in circuit, and the total extra induced currents from them and upon the condition of the wire, its resistance, and also upon the pressure and volume of current in use. I think, however, that as soon as the railway companies reach the point where they cannot, under any circumstances, communicate from one terminal to another in bad weather, and consequently cannot work with intermediate stations, they will probably be driven to some expedient to improve the condition of the line.

The secretary announced that the American Society of Mechanical Engineers was in session, for two days, at No. 12 West 31st street, the Academy of Medicine, and had invited the attendance of members of the Institute of Electrical Engineers.

The Chairman—As electrical engineers are nine-tenths mechanical engineers, according to the definition that Sir William Thomson has given of the electrical engineer, I have no doubt we would derive a good deal of instruction and benefit by availing ourselves of the invitation of Professor Hutton and his fellow officers and members of the Society of Mechanical Engineers.

I would like to announce that the subject of our next meeting, that of December, is a very important and interesting one, namely, "Transformer Tests," upon which subject we shall have the pleasure of hearing Professor Ryan, of Cornell University, who is associated with our esteemed vice-president, Professor Nichols. This paper will embody some very important data, and will be one of the most interesting of the season. The paper following that, in January, will be given by Professor Anthony on a subject yet to be named by him.

Adjourned.

.... THERE is one radiant enemy which appears to us as "actinic," or "luminous," or "thermal" radiation, according to the way we observe it.—*S. P. Langley.*

.... OUR great engineers and epoch-making men have never been, in the true sense of the term, school-men.—*S. Alfred Varley.*

GENERAL STATEMENT.

The following exhibit shows the revenues and disbursements of the company for twenty-three years from July 1st, 1866:—

Surplus of income account, July 1, 1866	$275,357.24	
Net revenue for twenty-three years, from July 1st, 1866, to June 30, 1889..	97,326,411.05	
Making an aggregate, June 30, 1889, of		$97,601,768.29

During this period there was applied:—

For cash dividends..................	$55,495,085.39	
For scrip dividends....................	1,199,852.06	
For cost of 59,606½ shares of Western Union Telegraph stock, purchased and owned by the company, which was distributed to stockholders in 1879...........................	3,302,198.90	
For cost of 72,010 shares of Atlantic and Pacific Telegraph stock, purchased and owned by the company, the proceeds of which, in Western Union stock, were distributed to stockholders in 1881.....	1,806,250.00	
For interest paid on company's bonds.	9,929,283.49	
For cost of 396 $\frac{4}{10}$ shares of Western Union stock, purchased and owned by the company, which were canceled to make the capital stock, after the issue of the new stock in 1881, exactly $80,000,000...	26,836.00	
For amount reserved for interest on bonds and for sinking funds, accrued to June 30, but then not yet due and payable.............................	106,086.64	
Leaving over and above dividends and		$71,865,592.48
fixed charges		$25,736,175.81

Which is represented as follows:—

Construction of new lines, erection of additional wires, patents, etc., prior to October 1, 1881..........	$9,541,172.38	
Purchase of telegraph lines and of the stocks of companies leased by the Western Union company (upon which interest or dividends are paid as rental) prior to October 1, 1881.......	2,448,182.66	
Gold and Stock Telegraph Co.'s stock (18,905 shares).................. . ..	1,176,009.00	
International Ocean Telegraph Co.'s stock (15,170 shares)........	961,606.42	
Brooks' Underground Telegraph Co.'s stock (1,000 shares)	95,000.00	
Southern Bell Telephone and Telegraph Co.'s stock (1,687 shares)......	84,325.00	
Sundry other stocks and bonds	88,062.50	
Western Union bonds redeemed and canceled.	1,528,293.40	
Sinking fund (portion not yet used for redemption of bonds, exclusive of interest allowed by trustees).	312,194.69	
Broadway and Dey street building $2,365,539.52		
Less amount provided from the proceeds of the bonds issued........ 1,802,202.00		
	563,337.52	
Real estate, other than above.........	144,300.38	
Supplies and material on hand unissued...................	182,290.08	
Surplus, June 30, 1889..................	8,611,401.78	
		$25,736,175.81
On account of these assets, a stock distribution was made in 1881 to the amount of...........................		15,526,590.00
Deducting which leaves a balance of..		$10,209,585.81

Of the $97,601,768.29 of net revenues shown in the foregoing statement, $56,694,937.45 has been distributed to stockholders in dividends; $5,135,284.90 was paid for the purchase of Atlantic and Pacific and Western Union stocks, which were also distributed in stock dividends in 1881; $10,035,370.13 was for interest and sinking fund on bonded debt; and the remainder, $25,736,-175.81, has been expended in the purchase and construction of additional telegraph properties of which $15,526,590.00 was capitalized by the issue and distribution of stock in 1881, leaving a surplus of $10,209,585.81 which is not represented by any form of capitalization. The surplus of $8,611,401.78 shown June 30, 1889, in the statement "Business of the Year," is that part of the surplus that has accumulated since October 1, 1881.

In addition to the expenditure of $25,736,175.81 from the earnings of the company, there have also been expended in construction the proceeds of $1,000,000.00 of bonds sold in 1884, and of $1,200,000.00 represented by scrip dividend; and in the purchase of securities of leased lines the proceeds of $5,361,000.00 of 5 per cent. bonds exchanged therefor, making $33,097,175.81 in cash and bonds expended in the plant, besides $28,400,000.00 of capital stock issued and paid directly for the purchase of telegraph properties; making about sixty-one and a half millions expended in the enlargement and extension of the plant since July, 1866, of which over ten millions, as above shown, remains uncapitalized.

Many of these properties were purchased at prices far below the cost of their production. This is true in every instance of purchases made during the past five years. The value of the lines constructed directly by the company, at a cost of more than twenty-eight millions of dollars, is very much greater than that sum. To the cash outlay should be added the value of the transportation and labor paid for in telegraph service under our contracts with railroad companies.

The additions to the property during the year were 7,379 miles of line, 31,449 miles of wire, and the equipment of 1,229 additional offices; of which 4,814 miles of line and 8,701 miles of wire were purchased and acquired under contracts with railroad companies, and 2,565 miles of line and 22,748 miles of wire were constructed directly by the company. There was expended for these acquisitions during the year out of the surplus earnings, $1,141,010.72.

The increase of wire mileage was necessary to cover new railroads and to meet the growing demands of the service generally.

The investment of earnings in new property during the year was nearly equal to one and one-half per cent. on the capital stock, and the returns already received demonstrate clearly that the investment is of more value to the stockholders than if paid to them in additional cash dividends.

The following table exhibits the growth and increase of the property and business of the company, the average rate of tolls collected on messages, and the average cost per message to render the service annually for twenty-three years:—

STATISTICS.

The following table exhibits the mileage of lines operated, number of offices, number of messages sent, receipts, expenses, profits and average tolls and costs per message for each year since 1866.

Year.	Miles of poles and cables.	Miles of wire.	Offices.	Messages.	Receipts.	Expenses.	Profits.	Average tolls per message.	Average cost to company of message.
1866	37,380	75,686	2,250	....	$	$	$		
1867	46,270	85,291	2,565	5,879,282	6,568,925.36	3,944,005.63	2,624,919.73	.....	....
1868	50,183	97,594	3,219	6,404,595	7,004,560.19	4,362,849.32	2,641,710.87	104.7	63.4
1869	52,099	104,584	3,607	7,934,933	7,316,918.30	4,568,116.85	2,748,801.45	89.3	54.2
1870	54,109	112,191	3,972	9,157,646	7,138,737.96	4,910,772.42	2,227,965.54	75.5	51.2
1871	56,032	121,151	4,606	10,646,077	7,637,448.85	5,104,787.19	2,532,661.66	69.5	45.7
1872	62,033	137,190	5,237	12,444,499	8,457,095.77	5,666,863.16	2,790,232.61	66.2	43.8
1873	65,757	154,472	5,740	14,456,832	9,333,018.51	6,575,055.82	2,757,962.69	62.5	43.4
1874	71,585	175,735	6,188	16,329,256	9,262,653.98	6,755,733.83	2,506,920.15	54.9	39.5
1875	72,833	179,496	6,565	17,153,710	9,564,574.60	6,335,414.77	3,229,157.83	54.	35.2
1876	73,532	183,832	7,072	18,729,567	10,034,983.66	6,635,473.69	3,399,509.97	50.9	33.5
1877	76,955	194,323	7,500	21,158,941	9,812,352.61	6,672,224.94	3,140,127.67	43.6	29.8
1878	81,002	206,202	8,014	23,918,894	9,861,355.23	6,309,812.53	3,551,542.70	38.9	25.
1879	82,987	211,566	8,534	25,070,106	10,360,640.46	6,160,200.37	4,800,440.09	38.6	25.2
1880	85,645	233,534	9,077	29,215,509	12,782,894.53	6,948,956.74	4,833,937.79	38.5	25.4
1881	110,340	327,171	10,737	32,500,000	14,393,543.85	8,485,264.13	5,908,279.72	38.4	25.6
1882	131,060	374,368	12,068	38,842,247	17,114,165.92	9,996,095.92	7,118,070.00	38.2	25.8
1883	144,294	432,726	12,917	41,181,177	19,454,902.98	11,794,553.40	7,660,349.58	38.	26.
1884	145,037	450,571	13,761	42,076,226	19,632,939.60	13,022,503.90	6,610,435.70	36.5	25.2
1885	147,500	462,283	14,184	42,096,583	17,706,833.71	12,005,909.58	5,700,924.13	32.1	24.9
1886	151,832	489,607	15,142	43,289,807	16,298,638.55	12,378,783.42	3,919,855.13	31.3	23.4
1887	156,814	524,641	15,658	47,394,530	17,191,909.95	13,154,628.54	4,037,281.41	30.4	23.
1888	171,375	616,248	17,241	51,463,955	19,711,164.12	14,640,592.18	5,070,571.94	31.2	23.2
1889	178,754	647,697	18,470	54,108,326	20,783,194.07	14,565,152.61	6,218,041.46	31.2	22.4

This table is worthy of close observation and study. It exhibits the growth and magnitude of a telegraph system that controls one-third of the telegraph mileage, operates about one-fourth of all the offices, and handles one-fourth of all the telegraph traffic of the world.

Its growth for ten years (comparing 1879 with 1889) has been in mileage of lines 115$\frac{4}{10}$ per cent., in mileage of wire over 206 per cent., in number of offices 116$\frac{4}{10}$ per cent., and in number of messages sent 115$\frac{8}{10}$ per cent. Its revenues have not correspondingly increased on account of the great reduction in rates of tolls. It will be observed that the average tolls collected on messages for the past four years is less than one-half the average cost to the company of handling messages twenty years ago.

SECURITIES.

The table appended, exhibiting the assets in the treasury, remains substantially the same as last year, with the addition of

tube connecting them siphoned the liquid from one to the other by alternately raising the level of the jars.

A number of resident graduates and seniors have started work preparatory to Theses. N. H. Genung is making the preliminary measurements for the determination of the electro-chemical equivalent of silver. This work will probably have the co-operation of Professor Ryan and Mr. Merritt. B. E. Moore and C. J. Ling are studying the diminution in efficiency with use of incandescent lamps, and intend to measure the amount and character of the light absorbed by the glass at various stages of life. L. B. Marks with the assistance of A. B. Levy continues the study of arc-light carbons, the subject of his thesis of last June. F. C. Caldwell has taken up the vexed question of the electrical properties of tellurium, and will probably devote the entire year to that subject.

The size of the graduating classes since the organization of the college as a school of mechanical and electrical engineering, is a good index of its rate of growth. There were five graduates in '86 all taking the first degree; 16 taking first and three taking second degrees in '87; 19 taking first and six taking second degrees in '88; and 27 taking first and five taking advanced degrees in '89 There are about 60 hoping to secure the first degree and 13 the advanced degree in '90. This number is almost equally divided between the two courses, those taking the course in electrical engineering being in the majority. Meantime the total number in attendance has risen from 40 or 50 to 380, and it is proposed to prepare for 400 next year.

A seminary has recently been formed that bids fair to be both agreeable and beneficial. The work is purely voluntary.

The plan is as follows:—

There are about 70 periodicals relating to mechanical and electrical subjects taken by the department. Of these about 30 have been selected as the most important, and each member of the seminary is assigned one publication. When the members meet each one reports upon the last number of the periodical assigned to him. He reads any article that he may think of special value, and discussion on the points involved follows. Seniors and graduates are admitted as members, and the professors engage in the work the same as the students. The work is under the direction of Professor A. W. Smith.

Massachusetts Institute of Technology.

The work of last year upon alternating current transformers is to be continued by Mr. W. L. Smith, who assisted Messrs. Fiske and French in their work last term. Converters of various types and capacities are to be tested with various loads, both by the electrometer and calorimeter methods, with a view to the comparison of the accuracy of the two methods.

The electrical department has received from J. White, Glasgow, a set of Sir Wm. Thomson's magneto-static instruments, both current and potential.

Mr. Puffer, instructor in physics, has under construction for the department a standard bridge.

Announcements of the Lowell free evening courses have appeared. There are three series of lectures on engineering and scientific subjects, viz.:—Elementary Electrical Measurements: 10 laboratory exercises, by Professor S. W. Holman, on Fridays, at 7 P. M., commencing November 8. The Theoretical Principles Underlying the More Important Practical Applications of Electricity: 12 lectures, by Professor Charles R. Cross, on Mondays and Wednesdays, at 7:30 P. M., beginning Nov. 11. Valve Gear Designing: 12 lectures, by Professor Peabody, on Tuesdays and Fridays, at 7.30 P. M., beginning Nov. 8.

Columbia College.

The apparatus for use in the electrical engineering course of the School of Mines, Columbia College, includes the best American and foreign instruments, such as the large Anthony bridge, Elliott bridge, Anthony standard galvanometer, Thomson's reflecting galvanometers, large and small (by Elliott), Thompson's ampere balance, Marshall standard multiple series condenser, Elliott standard condenser, sets of 100,000 ohm coils by Anthony and by Elliott, Weston, Ayrton and Perry, Cardew and Carpenter voltmeters and ampere meters. Besides these standard instruments, there are the instruments ordinarily employed in practical work, such as portable bridge and galvanometer sets, detector galvanometers.

There are also in the electrical engineering building a 100-light and a 300-light Edison dynamo of recent type, which are working and available for the use of the students. The building is also connected with the Edison street circuit as well as with the Manhattan alternating current circuit, thus giving excellent facilities for experiment.

A 5 h. p. Sprague electric motor is in use in the buildings, and other smaller motors will be employed in driving machines and apparatus in the laboratory.

Standard sets of telegraph, telephone and electric light apparatus, and primary and secondary batteries are also provided for the use of the students.

Both lectures and the laboratory work take up the subject from the very beginning, and a thorough drilling in fundamental principles is given. This is found to be very necessary even in the most elementary matters, and is probably the most important part of the entire course, is given.

The new course has started under very favorable circumstances with every prospect of being a benefit to the college and to electrical engineering.

GROWTH OF THE TELEGRAPH.

Almost half a century has elapsed since the telegraph was added to the lengthening list of the triumphs of human skill; but the most remarkable expansion of the telegraph business in this country has taken place in the last twenty years. The report of the Western Union Telegraph Co. for the year ending June 30, 1889, shows that since 1870 the company's lines of wire increased from 112,191 to 647,697 miles; the offices from 5,972 to 18,470; the messages sent from 9,157,646 to 54,108,326; the gross receipts from $7,138,737 to $70,783,193; the expenses from $4,910,772 to $14,565,-152; and the profits from $2,227,965 to $6,218,041. Notwithstanding the great increase of profits, the average charge per message has decreased from 75.5 to 31.2 cents. This arises from the fact that the average cost per message to the company has diminished from 51.2 cents to 22.4 cents, and its average profit from 24.3 cents to 8.8 cents. But while the average profit on each message is about one-third what it was in 1870, the number of messages is nearly six times as great.

ELECTRIC LIGHT AND POWER.

CINCINNATI, O., is taking active steps to light the entire city by electricity. Bids for the work are to be received in December.

THE ALLEGHENY COUNTY ELECTRIC LIGHT CO. will hold a meeting at Pittsburgh, Pa., on January 4, to consider increasing its capital stock. An increase of the capital is thought desirable in view of the probability that the number of incandescent and arc lights now in use will need to be increased fully one-half at an early period. Furthermore, the company expects that it will be compelled at some future day to put its wires underground, and it desires to be prepared for any emergency.

AT WASHINGTON, the Treasury Department has ordered a 2 h. p. electric motor to drive machines for numbering and canceling bank notes, bonds, etc. The order was given to the Sprague Electric Motor and Railway Co. upon competition as follows:—

R. B. Smith (Sprague motor)	$163
J. H. Bunnell	169
"C. & C." Electric Motor Co	185
Excelsior Electric Co	187 50
Jos. U. Burket & Co. (Perret)	200
Thomson-Houston Co	225
Eddy Electric Mfg. Co	250
Daft Electric Light Co	275

EAST PORTLAND, ORE.—H. A. Hogue who operates an extensive saw mill at East Portland, Ore., and in connection therewith, an incandescent electric lighting plant, has made arrangements to increase his plant largely, with a view of undertaking additional city lighting, and entering the field for commercial and domestic illumination. He has placed an order with the Heisler Electric Light Co., of St. Louis, for additional apparatus, which will increase his plant to three times its present capacity.

THE TORONTO ELECTRIC LIGHT CO. have well under way their underground system, and expect to have the station in running order by the first of December. There is talk of this company, the Toronto Electric Light Co., introducing an alternating system If they decide to do so, it will be interesting to see what will be the outcome. The Edison company claim exclusive privileges in incandescent lighting.

THE SPRAGUE ELECTRIC EQUIPMENT CO., of Chicago, has just completed the installation of a motor for turning the Wisconsin Central transfer table at Waukesha.

WOODHOUSE & RAWSON, Limited, notify us of an error in the notice "The Electric Light at the Paris Exhibition," which was reprinted from *Industries*, in THE ELECTRICAL ENGINEER, for May. In that notice it was stated that Woodhouse & Rawson furnished eight glow lamps of 200 c. p., whereas the house informs us it should have been stated as 200 glow lamps of 16 c. p.

Foreign.

Austria.—Lighting by means of alternating currents is making rapid headway here. Marienbad is the first important central station on this system in Austria-Hungary. Several smaller ones have since sprung up, and the temporary installation at the State railway station at Buda-Pesth is to be enlarged. Instead of the two 60 h. p. engines hitherto employed, there are to be two of 120 h. p. each. This installation will be used also for lighting the head post-office. Messrs. Ganz & Co. will carry out the new work.

GOVERNMENT TELEGRAPH RATES.

Postmaster-General Wanamaker receded from his extreme position of last June, and, under date of October 30th, promulgated the following rates to be paid by the government for telegraph service.

For day messages, containing not more than ten words, exclusive of place from, date, address and signature, 10 cents for all distances not exceeding 400 miles, and one-half cent for each word in excess of 10 words.

For distances exceeding 400 miles and not exceeding 1,000 miles, 15 cents for the first 10 words counted as above provided, and three-fourths of one cent for each word in excess of 10 words.

For all distances exceeding 1,000 miles there shall be added to the price of the message fixed for distances of over 400 and under 1,000 miles the sum of one-half cent for each word counted as above provided.

In cases where the price of a message determined as herein provided shall include a fraction of a cent, such fraction, if less than one half, is to be disregarded: if more than one-half, it is to be counted as one cent.

For night messages, if not exceeding twenty (20) words, exclusive of place from, date, address and signature, fifteen (15) cents for all distances, and one-half (½) cent for each additional word.

On November 6th the Executive Committee of the Western Union Telegraph Co. passed a resolution protesting against the rates fixed by Mr. Wanamaker, but expressing the purpose of the company to transmit all telegrams put into its hands by the government upon the conditions as to precedence of other business prescribed by the postmaster-general, but reserving all rights, under its protest, touching the compensation to be paid by the government for such service. The company is advised that it has legal remedies against the establishment of an arbitrary rate by the postmaster-general if such rate can be shown to be inequitable.

PERSONAL MENTION.

MR. CHAS. A. SCHIEREN, of the firm of Chas. A. Schieren & Co., has been appointed one of the committee for the International Exposition of 1892, to represent the leather belting industry.

MR. GEORGE F. PORTER, of Philadelphia, long connected with electric lighting interests through his association with the carbon trade, has joined the staff of the Westinghouse Electric Co.

MR. ALLEN R. FOOTE, who does not like "looking backward," will shortly direct general attention to "Looking Ahead; and How to Get There," in a book under that title which he is reported to have nearly ready for the press.

MR. W. H. BAKER's recent appointment to the vice presidency of the Postal Telegraph Co., is a particularly fit advancement. Mr. Baker has for many years been intimately connected with the executive department of the telegraph—in the Western Union and in other companies—winning appreciation for his ability and esteem for his courtesy.

MANUFACTURING AND TRADE NOTES.

LEONARD & IZARD CO., general agents for the central states of United Edison Manufacturing Co., formerly of 425, The Rookery, Chicago, have removed their offices to the Rialto Building, in the same city.

THE GARVIN MACHINE CO., Messrs. E. E. Garvin and Co., Laight and Canal streets, N. Y., announce that on November 13, they transferred all their right, title and interest in their firm to the Garvin Machine Co. The new company assumes all accounts whether due to or by the said firm. They bespeak for the new company a share of the patronage so liberally bestowed on the old firm in the past. The Garvin Machine Co. will continue at the present address, as above.

THE HILL CLUTCH WORKS, of Cleveland, O., through their eastern manager, Mr. Walter C. Wonham, report that they have just closed a contract with the Norwich (Conn.) Gas Light Co., for the complete equipment of their new electric light station with everything in the line of power transmission machinery and "Hill" friction clutch pulleys and couplings. The designs for this plant were made by Mr. L. J. Hirt, M. E., of the Hill Clutch Works.

THE WESTINGHOUSE MACHINE CO. regard October 1889, as their banner month. The sales reported are the largest in the company's history, and are as follows:—

35 Junior engines	1,095 h. p.
32 Standard engines	1,395 "
43 Compound engines	3,545 "
110 engines, aggregating.	6,035 h. p.

THE RHODES & KEESE ELECTRIC CO., Los Angeles, Cal., have recently installed a Thomson-Houston incandescent lighting plant of over 100 lamps at the Palace Restaurant in that city. An Otto gas engine of 15 h. p. furnishes the power, driving the dynamo at a speed of nearly 1,600 revolutions per minute. Gas for the engine is supplied by the Los Angeles Gas Co. Plants of this kind should do much to determine the relative cost of lighting by gas and by electricity. It is claimed in this case that the 100 16-candle electric lamps can be maintained at less cost than 75 equivalent gas jets from the mains of the gas company.

The Rhodes & Keese Co., with characteristic enterprise, are prepared to push the work of installing similar plants—and propose to supply smaller outfits for private houses, employing Otto gas engines as motive power.

THE WESTINGHOUSE ELECTRIC CO., and its leased companies, the Sawyer-Man and United States companies, report actual shipments of goods for four months as follows:—

July,	1889	$312,211 70
August,	1889	366,475 51
September,	1889	434,011 93
October,	1889	474,523 23
Total		$1,587,222 37

These figures do not include two large contracts for lighting in Allegheny, Penn., and San Francisco, Cal., each of which embraces an initial order of several thousand lamps.

THE total sales of central station alternating apparatus by the Westinghouse Electric Co., from the date of installation of its first plant in Buffalo, N. Y., in 1886, to November 1, 1889, aggregates a lamp capacity of 418,500, which will undoubtedly reach 450,000, when the returns for November are all in, a pretty good showing for three years' work.

MESSRS. CHAS. A. SCHIEREN & CO., of New York, believing that the purchasers and consumers of satisfactory articles like to know something of their manufacture, have prepared and issued in a tasteful folder, a very readable account of their factories, with the machinery and processes employed in producing their leather belting. The text is accompanied with numerous illustrations exhibiting various stages in the work of converting oak-tanned hides into finished belts for dynamos and all other machinery.

MESSRS. W. R. OSTRANDER & CO., 21-25 Ann street, New York, have recently sent out the seventh edition of their catalogue of speaking tube and electric bell apparatus and supplies. Their business has reached such dimensions that an octavo pamphlet of 104 pages is filled with descriptions, lists and prices of their products and wares. It may be said that what they offer to householders and to the trade covers well-nigh every requisite for indoor communication. The Ostrander house is too well known to need further mention of its scope and standing.

THE THOMSON-HOUSTON ELECTRIC CO. reports the following sales to local companies, with the number of lamps in each case. Incandescent:—Athens, Ga., 650; Somerville, Mass., 650; Elizabeth, N. Y., 650; Tuscaloosa, Ala., 650; Sioux Falls, Dak., 75; Hastings, Minn., 300; Huntington, Pa., 650; Ottumwa Railway Electric and Steam Co,, Ottumwa, Ia., 1,300. Arc:—Shenandoah, Pa., 50; Lebanon, Pa., 50; Atlanta, Ga., 50; Lima, Ohio, 50; East River Co., New York, 90; Jeffersonville, Ind., 50; Huntington, Pa., 50; Jersey City, N. J., 200; Burlington Gas Light Co., Burlington, Ia., 50; Columbus Electric Light and Power Co., Columbus, O., 100; Adrian Electric Light Works, Adrian, Mich., 45; Southside Electric Co., Chicago, Ill., 50; Springfield Electric Light and Power Co., Springfield, Ill., 50; Ionia Electric Co., Ionia, Mich., 30; Ottumwa Railway Electric and Steam Co., Ottumwa, Ia., 75.

The same company report sales of isolated plants as follows:—Arc:—Feister Printing Co., Chester, Pa., 20; B. Nugent & Co., St. Louis, Mo., 35; Balatka Bros., Chicago, Ill., 6; Williams & Jerrems, Chicago, Ill., 35; Barnum & Richardson Mfg. Co., Chicago, Ill., 6; Armour & Co., Chicago, Ill., 70; B. F. Draper, Ligonier, Ind., 30; The Charles Block, Denver, Col., 300. Incandescent:—W. B. Durgin, Concord, N. H., 200; Springfield Foundry Co., Springfield, Mass., 200; Elkhorn Mining Co., Bowlder, Mont., 200; Putnam Nail Works, Neponset, Mass., 400; The Okonite Co., Passaic, N. J., 400; Buchanan & Lyall, Brooklyn, N. Y., 400; Standard Cordage Co., Boston, Mass., 400; F. A. Kennedy, Cambridge, Mass., 400; Dunn & McCarty, Auburn, N. Y., 400; Kearney Paper Co., Kearney, Neb., 50.

GEORGE CUTTER, of Chicago, has been awarded the contract for building a telegraph line from Oshkosh, Wis., to Marquette, Mich., by the Chicago, Milwaukee and Lake Superior Telegraph Co.

THE ATWOOD ELECTRIC CO. has been incorporated. Its headquarters are at East St. Louis, Ill. The company will manufacture electric head-lights for locomotives. The capital stock is $500,000, and the incorporators are L. C. Atwood, E. B. Roth and C. C. Weaver.

THE ALUMINUM PRODUCING CO., of Chicago, has been incorporated with a capital stock of $600,000. The incorporators are H. G. Bruson, H. Booth and E. P. Hard.

THE CHICAGO PHONOGRAPH CO. has been organized with a capital stock of $750,000 by C. W. Drew, F. S. James and W. M. Tyler.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Akron, Ohio	Akron Electric Ry. Co	6.5	21	Sprague.
Albany, N. Y.	W't'rvliet T'npike&R.R.Co.	15.5	16	Thomson-Houston.
Atlanta, Ga	Atl'nta & Edg'w'dSt.Ry.Co.	4.5	4	Thomson-Houston.
Atlanta, Ga	Fulton Co. St. Ry. Co	9	10	Thomson-Houston.
Allegheny, Pa	Obs'rvat'y Hill Pass.Ry.Co.	3.7	6	Bentley-Knight.
Alliance, Ohio	Alliance St. Ry. Co	2	3	Thomson-Houston.
Ansonia, Conn	Derby Horse Ry. Co	4	4	Thomson-Houston.
Appleton, Wis	Ap. Electric St. Ry. Co	5.5	6	Van Depoele.
Asbury Park, N. J	Seashore Electric Ry. Co	4	20	Daft.
Asheville, N. C	Asheville Street Railway	3.5	5	Sprague.
Atlantic City, N. J	Pennsylvania R. R. Co	6.5	16	Sprague.
Baltimore, Md	Balt. Union Pass. Ry. Co	2	4	Daft.
Bangor, Me	Bangor Street Railway Co	5	5	Thomson-Houston.
Bay Ridge, Md	Bay Ridge Electric R. R	2	2	Sprague.
Binghamton, N. Y	Washington St., Asylum & Park R. R	5	4	Sprague.
Boston, Mass	West End St. Ry. Co., Harvard Square Branch	15	82	Thomson-Houston.
Brockton, Mass	East Side Street Ry. Co	4	4	Sprague.
Buffalo, N. Y	Buffalo, St. Ry. Co	2.5	4	Sprague.
Cincinnati, O	Cinc. & Inclined Plane Ry	6	20	Sprague.
Cincinnati, O	Colerain Ave. Ry. Co.	5	12	Thomson-Houston.
Chattanooga, Tenn	Chat. Elec. St. Ry. Co	5	6 2	Sprague. Thomson-Houston.
Cleveland, Ohio	East Cleveland Railroad Co.	12	50	Sprague.
Cleveland, O	Brooklyn St. Ry. Co	10	36	Thomson-Houston.
Columbus, Ohio	Columbus Consolidated St. Railway Co	2	2	Short.
Crescent Beach, Mass	Lynn & Boston St. Ry. Co.	1	1	Thomson-Houston.
Davenport, Iowa	Davenp'rt Cent. St. Ry. Co.	3.5	6	Sprague.
Danville, Va	Danville St. C. Co	2	6	Thomson-Houston.
Dayton, Ohio	White Line St. R. R. Co	9	12	Van Depoele.
Decatur, Ill	Citizen's Electric St. Ry	5	8	Thomson-Houston.
Decatur, Ill	Decatur Electric St. Ry	3	1	Nat.Elec.Tract.Co.
Des Moines, Iowa	Des Moines Elect. Ry. Co	10	19	Thomson-Houston.
Detroit, Mich	Detroit Electric Ry. Co	4	2	Van Depoele.
Detroit, Mich	Highland Park Ry. Co	3.5	4	Fisher.
Easton, Pa	Lafayette Traction Co	1	2	Daft.
Eau Claire, Wis	Eau Claire St. Ry	5	6	Sprague.
Erie, Pa	Erie City Pass. R. R. Co	12	15	Sprague.
Fort Gratiot, Mich	Gratiot Electric Railway	2	2	Van Depoele.
Harrisburg, Pa	East Har'sb'rg Pass. Ry.Co.	7.5	10 1	Sprague. Thomson-Houston.
Hartford, Conn	Hartford and Weathersfield Horse Railroad Co	3	3	Sprague.
Huntington, W. Va	Huntingt'n Elec. St. Ry. Co.	3.5	2	Short.
Ithaca, N. Y	Ithaca Street Railway Co	1	2	Daft.
Jamaica, N. Y	Jamaica & Brooklyn R. R.	9	10	Van Depoele.
Kansas City, Mo	Vine St. Ry	3	6	Thomson-Houston.
Kansas City, Mo	Metropolitan St. Ry. Co	5.5	12	Thomson-Houston.
Lafayette, Ind	Lafayette Street Ry. Co	3	9	Sprague.
Laredo, Texas	Laredo City R. R.	4	4	Sprague.
Lima, Ohio	The Lima Street Railway Motor and Power Co	6	7	Van Depoele.
Los Angelos, Cal	Los Angelos Elec. Ry. Co.	5	4	Daft.
Louisville, Ky	Central Pass. Ry. Co	10	12	Thomson-Houston.
Lynn, Mass	Lynn & Boston Ry. Co. (Crescent Beach)	1	1	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Highland Line)	2	3	Thomson-Houston.
Lynn, Mass	Lynn & Boston R. R. Co. (Nahant Line)	.8	1	Thomson-Houston.
Lynn, Mass	L. & B. R. R. Myrtle St. Line	3	5	Thomson-Houston.
Mansfield, Ohio	Mansfield Elec. St. Ry. Co	4.5	5	Daft.
Marlboro, Mass	Marlboro St. Ry. Co	3	4	Sprague.
Meriden, Conn	New Horse Railroad	5	12	Daft.
Meriden, Conn	Meriden Horse R. R. Co	5	12	Daft.
Nashville, Tenn	McGavock & Mt. Vernon St. Ry	3	26	Thomson-Houston.
Newark, N. J	Essex Co. Pass. Ry. Co	2.5	4	Daft.
New York, N. Y	N. Y. & Harlem (Fourth Avenue) R. R. Co	18.5	10	Julien.
New Orleans, La	....		1	Daft m'tr and Gitson st'ge battery.
Newport, R. I	Newport St. Ry. Co	4.5	6	Thomson-Houston.
Newburyport, Mass	Newburyport & Amesbury Horse Ry. Co	6	2	Thomson-Houston.
North Adams, Mass	Hoosac Valley Street Ry	5	6	Thomson-Houston.
Omaha, Neb	Omaha & Council Bluffs Railway and Bridge Co	14	24	Thomson-Houston.
Omaha, Neb	Omaha Motor Ry. Co	26	30	Thomson-Houston.
Omaha, Neb	Omaha Horse R. R	10	20	Sprague.
Omaha, Neb	Omaha &Co'ncil BluffsR.R.	4	2	Sprague.
Ottawa, Ill	Ottawa Electric St. Ry. Co	8	8	Thomson-Houston.
Ottumwa, Ia	Ottumwa St. Ry. Co	5	4	Thomson-Houston.
Peoria, Ill	Central Ry. Co	10	15	Thomson-Houston.
Plymouth, Mass	Plym'th & Kingston Ry.Co.	4.5	3	Thomson-Houston.
Port Huron, Mich	Port Huron Electric Ry	4	6	Van Depoele.
Quincy, Mass	Quincy & Boston St. Ry	9	4	Thomson-Houston.
Reading, Pa	East Reading R. R. Co	2	4	Sprague.
Revere, Mass	Boston & Revere Elec. St. Ry. Co	4	5	Thomson-Houston.
Richmond, Va	The Richmond Union Pass. Railway Co	13	40	Sprague.
Richmond, Ind	Richmond St. Ry. Co	4	6	Thomson-Houston.
Rochester, N. Y	Rochester Electric Ry. Co	7	9	Thomson-Houston.
Salt Lake City, Utah	Salt Lake City R. R. Co	6.5	20	Sprague.
Salem, Mass	Naumkeag Street Ry. Co	2	6	Sprague.
San Diego, Cal	San Diego Street Ry. Co	9	4	Henry.
Seattle, Wash. Ter	Seattle Electric Railway and Power Co	5	13	Thomson-Houston.
St. Catherine's, Ont	St.Catherine's, Merritton & Thorold Street Ry. Co	7	10	Van Depoele.
St. Joseph, Mo	St. Jos. Union Pass. Ry. Co.	6	14	Sprague.
St. Joseph, Mo	Wyatt Park Railway Co	10	8	Sprague.
St. Joseph, Mo	Wyatt Park Ry. Co. (Northern Division)	4.5	12	Sprague.
St. Joseph, Mo	People's R. R. Co	10	18	Sprague.
St. Louis, Mo	Lindell Ave. R. R	5.5	12	Sprague.
St. Louis, Mo	So. Broadway Line	3	13	Short.
Scranton, Pa	The People's Street Ry	12	20	Sprague.
Scranton, Pa	Scranton Suburban Ry. Co.	5	10	Thomson-Houston.
Scranton, Pa	Nay Aug Cross-Town Ry	1.5	3	Thomson-Houston.
Scranton, Pa	Scranton Passenger Ry	2	4	Thomson-Houston.
Southington, Conn	Southington & Plantsville Ry. Co	2	2	Thomson-Houston.
Syracuse, N. Y	Third Ward St. Ry. Co	4	8	Thomson-Houston.
Steubenville, Ohio	Steubenville Elec. Ry. Co	2.5	8	Sprague.
Stillwater, Minn	Stillwater Electric St. Ry	5	6	Sprague.

Electric Street Railways in America now in operation.—*Continued.*

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Toledo, O.	Toledo Electric Ry. Co	2	2	Thomson-Houston.
Topeka, Kan	Topeka Rapid Transit Co	17	30	Thomson-Houston.
Troy, N. Y	Troy & Lansingb'g St. R.R	5	12	Sprague.
Washington, D. C	Eckington & Soldiers'Home Electric Railway Co	3	10	Thomson-Houston.
Wheeling, Va	Wheeling Railway Co	10	5	Thomson-Houston.
Wichita, Kan	Riverside & Sub'ban Ry.Co.	9	6	Thomson-Houston.
Wilkesbarre, Pa	Wilkesbarre & Suburban Street Railway Co	3	8	Sprague.
Wilmington, Del	Wilmington City Ry. Co	3	8	Sprague.
Windsor, Ont	Windsor Elec. St. Ry. Co	2	2	Van Depoele.

Total—Roads **107**
" **Miles** **636.5**
" **Motor Cars**.......**1063**

Constructing or Under Contract.

Location.	Operating Company.	Length in Miles	No. of M. Cars	System.
Adrian, Mich	Adrian City Belt Line Elec. Ry. Co	3	4	Rae.
Albany, N. Y	Albany Ry. Co	14	32	Thomson-Houston.
Attleboro, Mass	No. Attleboro & Wrentham St. Ry. Co	8	5	Thomson Houston.
Americus, Ga	Americus St. Ry. Co	5.5	4	Thomson-Houston
Auburn, N. Y	Auburn Electric Ry. Co	3	3	Thomson-Houston.
Boston, Mass	West End St. Ry. Co., City Line, Boylston & Beacon Streets	191	218	Thomson-Houston.
Canton, O	Electric R. R	6	9	Sprague.
Cincinnati, O	Cincinnati St. Ry. Co	2.7	8	Thomson-Houston.
Cincinnati, Ohio	Mt. Adams & Eden Park Inclined Railway Co	4	16	Thomson-Houston.
Chattanooga, Tenn	Chattan'ga Elec. St. Ry.Co.		2	Thomson-Houston.
Cleveland, O	B'way & Newb'ugh St. Ry.	10	16	Sprague.
Cleveland, O	East Cleveland St. R. R., Prospect St Line	5	24	Sprague.
Dallas, Texas	West Dallas St. R. R	3	2	Sprague.
Dayton, O	Soldier's Home R. R	5	2	Sprague.
Detroit, Mich	E.Detr't& Grosse Pointe Ry	8		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit City Railway, Mack Street line	2		Nat.Elec.Tract.Co.
Detroit, Mich	Detroit, Rouge River & Dearborn R. R	1	1	Sprague.
Denver, Col.	Univ'y Park Ry. & Elec. Co.	4	8	Thomson-Houston.
Denver, Col	So. Denver Cable Co	2	2	Sprague.
Denver, Col	Denver Tramway Co	5	16	Thomson-Houston.
Dubuque, Ia	Key City Electric Ry	2	2	Sprague.
Elkhardt, Ind	Citizens Street Railway	7		Nat.Elec.Tract.Co.
Fort Worth, Texas	Fort Worth City Ry. Co	10		Nat.Elec.Tract.Co.
Fort Worth, Texas	FortWorth L'd & St. Ry.Co.	15		Nat.Elec.Tract.Co.
Joliet, Ill	Joliet St. Ry	3	4	Thomson-Houston.
Kansas City	No. East St. Ry. Co	7	10	Thomson-Houston.
Kearney, Neb	Kearney St. Ry. Co	8	2	Thomson-Houston.
Knoxville, Tenn	Knoxville St. R. R. Co	2	5	Thomson-Houston.
Long Island City, N.Y.	Long Island City & Newton Electric R. R	3	2	Sprague.
Lynn, Mass	Belt Line Ry. Co	4.5	4	Thomson-Houston.
Moline, Ill	Moline St. R. R	21	2	Sprague.
Macon, Ga	Macon City & Sub'n Ry.Co.	6.25	8	Thomson-Houston.
Manchester, Va	Richmond & Man. Ry. Co	3.5	10	Sprague.
Milwaukee	Milwaukee Cable Co	5	12	Thomson-Houston.
Milwaukee, Wis	West Side R. R	7	10	Sprague.
Minneapolis, Minn	Minneapolis Street Ry. Co.	6.5	6	Sprague.
Minneapolis, Minn	Minneapolis St. Ry. Co	8	10	Thomson-Houston.
Muskegon, Mich	Muskegon Elec. Ry. Co	4.5	5	Short.
Nashville, Tenn	So. Nashville St. R. R. Co	6	10	Sprague.
Nashville, Tenn	Nashville & Edgefield R. R.	6	10	Sprague.
Nashville, Tenn	City Elect. St. Ry	3.5	6	Thomson-Houston.
Nashville, Tenn	Nashville St. R. R	5	8	Sprague.
Newton, Mass	Newton St. Ry. Co	8	10	Thomson-Houston.
Newark, O	Newark & Granville St. Ry.	.5	1	Sprague.
New York, N. Y	North & East River Ry. Co.	3	20	Bentley-Knight.
Ontario, Cal	Ont. & S. Ant. Hei'ts Ry.Co.	8	4	Daft.
Passaic, N. J	Passaic St. Ry	3	3	Thomson-Houston
Piqua, O	Piqua Electric R. R	3.5	4	Sprague.
Pittsburgh, Pa	Federal Street & Pleasant Valley R. R	8½	31	Sprague.
Pittsburgh, Pa	Pittsburgh Suburban Rapid Transit Co		3	Daft.
Pittsburgh, Pa	Squirrel Hill R. R	3½	5	Sprague.
Pittsburgh, Pa	Second Ave. Pass. Ry. Co	10	10	Thomson-Houston
Plattsmouth, Neb	Plattsmouth Electric R. R	2	2	Sprague.
Port Chester, N. Y	P. C. & Rye B'ch St.Ry.Co.	3	5	Daft.
Portland, Oregon	Metropolitan R. R	3	7	Sprague.
Portland, Ore	Willamette Bridge Co	1.5	5	Sprague.
Portland, Ore	Multnomah R. R	5	10	Sprague.
Portland, Ore	Woodst'ck & Waverly Elec. Ry. Co	5.25	4	Thomson-Houston.
Red Bank, N. J	Red Bank & Seabright Ry.	5	8	Thomson-Houston.
St. Louis, Mo.	St. Louis Bridge Co	2	4	Thomson-Houston.
St. Louis, Mo	Union Depot Ry	10	30	Thomson-Houston.
St. Paul, Minn.	St. Paul City Ry	51	20	Thomson-Houston.
St. Paul, Minn	St. Paul & Minneapolis Ry.	20	20	Thomson-Houston.
Salem, Mass	Naumkeag St. Ry	3	6	Thomson-Houston.
San Jose, Cal	San Jose & Santa Clara R. R. Co	9	6	Thomson-Houston.
Sarat'ga Springs, N.Y.	Saratoga Electric Ry. Co	2	2	Thomson-Houston.
Sault Ste. Marie, Mich	Sault Ste. Marie St. Ry. Co.	2		Fisher.
Scranton, Pa	Hillside Coal Co	1	1	Thomson-Houston.
Sioux City, Dak.	Sioux City St. Ry	6	12	Sprague.
Sherman, Tex	College Park Elec. Belt Line	4	5	Sprague.
South St. Paul, Minn.	So. St. P. Rapid Transit Co.	8	10	Sprague.
Spokane Falls, W. T.	Ross Park St. Ry. Co	7.50	6	Thomson-Houston.
Springfield, Mo				Fisher.
Sterling, Ill	Union Electric R. R	6	7	Sprague.
Sunbury, Pa.	Sunbury& N'th'land Ry.Co.	3½	3	Daft.
Tacoma, Wash. Ter	Pacific Ave. St. R R	6	8	Sprague.
Tacoma, Wash. Ter	Tacoma Ave. St. Ry. Co	2	8	Sprague.
Toronto, Ont.	Metropolitan St. Ry	3	2	Thomson-Houston.
Vancouver Island	Victoria Electric St. Ry.Co.	4	4	Thomson-Houston.
Victoria, B. C	Natl. Elec. Tram. & Ltg. Co.	4	4	Thomson-Houston.
Washington, D. C	Georget'wn, Tenalleytown St. Ry. Co	6	6	Thomson-Houston.
Wilkesbarre, Pa	Wilkesb're & W. Side R. R.	4	3	Sprague.
Worcester, Mass	Worcester & Shrewsbury	2.7		Daft.
West Bay City, Mich.	WestBay City Elec. Ry. Co.	5	8	Sprague.
Youngstown, O	Electric R. R	5	[illegible]	Sprague.

Total—Roads............. **85**

MISCELLANEOUS.

In the United States Supreme Court on November 4, a decision was rendered in the appealed case of Brush *vs.* Condit, affirming the decision of the Circuit Court in favor of the defendants. This suit was, in fact, a suit by the Brush Electric Co. against the United States Electric Lighting Co., alleging infringement of reissued patent No. 8,718 of Charles F. Brush, for ring-clutch mechanism for electric arc lamps. The opinion of the lower Court may be found in vol. , page , of the ELECTRICAL ENGINEER. The patent was declared void by reason of prior public use at the Wallace factory in Ansonia, Conn., of the arc lamp invented and constructed by Charles H. Hayes, which was, however, operated but a few weeks and was then thrown aside. It was, nevertheless, found by the Court that this use was sufficient to invalidate the patent, and this view of the case is now concurred in by the Supreme Court, and the Brush patent accordingly becomes void.

In the Brush-Julien suit relating to the construction of storage batteries, the Electrical Accumulator Co. has moved for an intervention alleging collusion between the litigants, it being claimed, probably not without substantial reason, that a coalition of some sort has been entered into between the Brush and Julien companies. At the time of going to press Judge Coxe had not decided the motion.

In the old case of the Edison Electric Light Co. against the United States Electric Lighting Co., known as the high resistance carbon filament case, the complainants are still taking testimony in support of their *prima facie* case. Nothing has been done during the past month in the other cases pending between the same parties.

INVENTORS' RECORD.

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From October 22 to November 12, 1889 (inclusive).

Alarms and Signals:—*Electric Signaling Apparatus*, W. E. Decrow, 413,436, *Annunciator*, F. E. Fisher, 413,504. *Thermostatic Alarm*, C. H. Shaffer. 413,568, October 22. *Electric Fire Signal*, C. B. Head, 414,155, October 29. *Thermostat*, H. E. Thompson, 414,267. *Burglar Alarm*, A. A. Goucher, 414,308. *Tell-Tale Apparatus for Ship Telegraphs*, W. T. W. Thackeray and I. Hurn, 414,343. *Electric Bell*, E. Cox-Walker and A. A. C. Swinton, 414,612, November 5. *Alarm Attachment for Gas Burners*, E. L. Harrison, 414,883. *Annunciator*, A. T. Hess, 415,182, November 12.

Clocks:—*Electric Pendulum-Driven Clock*, M. L. M. Hussey, 413,281. *Electric Regulator for Pendulum Clocks*, J. H. Gerry, 413,340, October 22.

Conductors, Insulators and Conduits:—*Underground Conduit*, G. H. Warde, 413,215, October 22. *Conduit for Electric Wires*, J. W. Richards and J. B. Hall, 414,327, November 5. *Conduit for Underground Wires*, H. B. Camp, 414,970. *Method of Ventilating Subways*, I. LaR. Johnson, 415,110, November 12.

Distribution:—*Electric Regulator*, W. Hochhausen, 413,279. *System of Electrical Distribution*, E. Thomson and E. W. Rice, Jr., 413,293. *Method of Obtaining Direct from Alternating Currents*, N. Tesla, 413,353. *Transformer or Converter for Alternating Electric Currents*, L. Paget, 413,810, October 22. *Electric Current Regulator*, F. Thone, 413,984. *Electric Regulator*, L. Gutmann, 414,043, October 29. *Electrical Regulating Apparatus*, H. J. Conant, 414,191. *Iron-Cased Induction Coil for Alternating Current Transfer*, E. Thomson, 414,266. *System of Electrical Distribution by Alternating Currents*, J. Hopkinson, 414,541, November 5. *Electric Motor Support*, S. H. Short, 415,070, November 12.

Dynamos and Motors:—*Switch for Dynamo-Electric Machines*, W. Hochhausen, 413,280. *Dynamo-Electric Machine*, R. Eickemeyer, 413,337 and 413,363, October 22. *Alternate Current Induction Motor*, C. J. Van Depoele, 413,986. *Method of Regulating Electric Motors*, M. Immisch, 414,052, October 29. *Ring Armature for Electric Generators*, G. Pfannkuche, 414,245. *Time-Recording Device for Dynamo-Electric Machines*, H. C. Spaulding, 414,339. *Dynamo-Electric Machine*, W. Seafert, 414,659, November 5. *Electric-Fan Motor*, P. Diehl, 414,757. *Electric Motor Fan*, same, 414,758. *Dynamo-Electric Machine*, H. Geisenhonor, 414,900, November 12.

Galvanic Batteries:—*Galvanic Battery Compound*, W. P. Kookogey, 413,345. *Process of Manufacturing Battery Zincs*, F. F. Eggers, 413,438, October 22, *Diaphragm for Galvanic Batteries*, I. L. Roberts, 414,081, October 29. *Electric Battery*, C. A. Hussey, 414,220. *Battery Carbon*, same, 414,317. *Electric Battery*, same, 414,318; J. A. Barrett, 414,627, November 5.

Ignition:—*Automatic Circuit Making and Breaking Mechanism for Gas Lighting*, W. W. Estabrook, 414,763, November 12.

Lamps and Appurtenances:—*Electric Car Lighting*, S. H. Barrett, 413,160, *Holding Attachment for Arc-Lamps*, T. H. Brady, 413,220. *Incandescent Lamp*, E. F. Gennert, 413,442. *Electric Lamp*, J. T. Van Gestel, 413,636, October 22. *Arc Lamp*, F. W. R. Seifert, 414,130; F. G. Chapman and F. M. Dearing, 414,141, October 29. *Electric Light Post*, P. J. Dinn, 414,686. *Incandescent Electric Lamp*, G. W. Wilson, 414,741 and 414,742. *Cut-Out for Incandescent Lamps*, T. D. Bottome, 414,792. *Electric Light Support*, A. Dawes, 414,798. *Incandescent Lamp Socket*, S. Rodman, Jr., 414,922. *Street Lamp Post for Electric Lamps*, F. U. Adams, 414,933, November 12.

Measurement:—*Electric Measuring Instrument*, E. Thomson, 413,292, October 22. *Galvanometer*, A. M. Ritchie, 413,812, October 29; J. E. Lockwood, 414,422. *Meter for Alternating Electric Currents*, O. B. Shallenberger, 414,595, November 5.

Medical and Surgical:—*Galvanic Belt*, W. Laughton, 414,668, November 5.

Metal Working:—*Apparatus for Obtaining Sheets of Metal by Electro-Deposition*, C. C. Coffin, 415,024, November 12.

Miscellaneous:—*Automatic Recording Compass*, C. O. Farciot, 413,250. *Fire Escape*, O. T. Welch, 413,270. *Phonograph*, W. W. Jacques, 413,282. *Weighing Apparatus*, W. Snelgrove, 413,331. *Magnetic Gauge for Testing the Magnetic Conductivity of Metals*, W. Eickemeyer, 413,338. *Electro-Magnet*, D. S. McElroy, 413,411. *Electric Switch*, R. C. Hull, 413,512. *Revolving Tower Fortification*, T. R. Timby, 413,581, October 22. *Multiple Thermal Cut-Out*, A. Wurts, 413,703. *Metallic Circuit*, H. F. Campbell, 413,707. *Electric Safety-Lamp for Miners*, T. Coad, 413,708. *Method of Automatically Closing an Interrupted Electric Circuit*, L. Schaefer, 413,735. *Anti-Induction System*, J. O. Stockwell and A. Barrett, 413,795. *Combined Binding-Post and Thermal Cut-Out*, H. C. Root, 413,813. *Electric Stop-Motion for Twisting Machines, etc.*, V. I. Cumnock, 414,025. *Electric Current Indicator*, G. Pfannkuche, 414,076, October 29. *Electric Resistance Indicating Device*, C. D. Haskins and C. E. Scribner, 414,310. *Lightning Arrester*, C. Wirt, 414,356. *Matrix-Making Machine*, G. A. Goodson, 414,399 and 414,400. *Lightning Arrester*, C. I. Young, 414,624. *Induction Coil Apparatus*, J. A. Barrett, 414,626. *Device for Converting Motion*, G. A. Goodson, 414,637, November 5. *Electro-Mechanical Tripping Machine*, T. F. Gaynor, 414,695. *Electric Heater*, M. B. Leonard, 414,714. *Phonogram Blank*, T. A. Edison, 414,759. *Phonograph*, same, 414,760. *Phonogram Blank*, same, 414,761. *Sight-Exhibiting Machine*, F. Euphrat, 414,764. *Clamp for Holding Articles to be Electro-Plated*, W. A. Dunlap, 414,860. *Electric Current Indicator*, J. F. Mehren, 414,866. *Electric Indicator*, F. E. Morgan, 414,868; D. W. Edgecomb and C. A. Terry, 414,879. *Manufacture of White Lead*, T. D. Bottome, 414,935. *Method of Utilizing Natural Electric Energy*, M. W. Dewey, 414,913. *Mechanical Cut-Out*, J. W. Battershall, 414,966. *Temperature-Regulating Apparatus*, D. W. Thompson, 415,007, November 12.

Railways and Appliances:—*Contact Trolley for Electric Railway Cars*, J. Mitchell, 413,287. *Conduit for Electric Railways*, E. Thomson, 413,294. *Railway Train Signal*, D. S. McElroy, 413,409. *Electro-Magnetic Railway Signal*, same, 413,410. *Electrically Operated Railway Switch*, same, 413,412. *Electric Railway*, R. M. Hunter, 413,604. *Electric Railway System*, M. Wheless, 413,637, October 22. *Conduit for Electric Railways*, C. P. Poole, 413,731. *Device for Suspending Electric Conductors for Electric Railways*, T. E. Adams, 413,818. *Electric Train Signal*, W. Winder, 413,879. *Truck for Cable or Electric Cars*, S. A. Bemis, 413,890. *Brake for Electric Cars*, L. Pfingst, 413,960. *Electric Railway*, R. M. Hunter, 414,049 and 414,050; F. J. Sprague and P. F. O'Shaughnessy, 414,172, October 29. *Tower Wagon for Electric Street Car Service*, T. L. Johnson, 414,222. *Switch for Electric Motor Trolleys*, W. Christy, 414,289. *Electric Signal and Brake Device*, J. F. and C. A. Cox, 414,295. *Electric Train Brake System*, H. W. Leonard, 414,418. *Brake for Electric-Car Trucks*, L. Pfingst and S. A. Bemis, 414,575. *Trolley for Electric Railways*, J. M. Reams, 414,583. *Spring Switch for Overhead Electric Conductors*, C. J. Van Depoele, 414,609. *Electric Railway Signal*, W. P. Kookogey, 414,615, November 5, and 414,773. *Combined Electro-Magnetic Brake and Traction-Increasing Device*, E. E. Ries, 414,996 *Electric Locomotor*, J. R. Finney, 415,165, November 12.

Secondary Batteries:—*Mold for Casting the Plates of Storage Batteries*, W. Shapleigh, 413,309. *Secondary Battery*, R. Eickemeyer, 413,339, October 22. *Machine for the Manufacture of Secondary Battery Plates*, H. H. Carpenter, 414,288. *Secondary Battery*, H. G. Osburn, 414,438, November 5; W. Roberts, 414,953, November 12.

Telegraphs:—*Telegraph-Key*, E. S. Crull, 413,848, October 29. *Quadruplex Telegraphy*, C. P. Carr, 414,492, November 5.

Telephones and Appliances:—*Central Station Calling Apparatus*, I. H. Farnham, 413,276. *Telephone Receiver*, C. Selden, 413,308, October 22. *Telephone Diaphragm*, A. W. Hall, 413,782. *Electric Mechanism for Operating Telephone Call-Bells*, F. W. A. Schneider, 414,085. *Telephone Supporting Device*, S. J. Adams, 414,132. *Mechanical Telephone Exchange*, G. F. Shaver, 414,170, October 29. *Mechanical Telephone*, J. C. Bates, 414,280, November 5. *Telephone Receiver Holder*, H. M. Wilson, 414,961, November 12.

EXPIRING PATENTS.

Patents relating to Electricity which becomes Public Property in December, 1889.

Reported by F. B. Brock, *Patent Attorney*, 639 *F. street*, *Washington, D. C.*

Insulator, H. J. Rogers, 133,595, December 3, 1872. *Key*, J. Olmsted, 133,797 December 10, 1872. *Electrical Tool*, T. A. Edison, 133,841, December 10, 1872. *Electro-Magnet*, W. E. Davis, 133,968, December 17, 1872. *Annunciator*, O. Hagendorf, 134,053, December 17, 1872. *Telegraph*, H. Highton, 134,140, December 24, 1872. *Railway Car Telegraph*, R. K. Boyle, 134,246, December 24, 1872. *Battery*, A. G. Davis, 134,364, December 31, 1872. *Electrical Boat Steering*, H. J. Smith, 134,493, December 31, 1872.

PATENT OFFICE.

Edward P. Thompson, Specialist,

AS

Attorney in Soliciting Domestic and Foreign Patents for Electrical Inventions,

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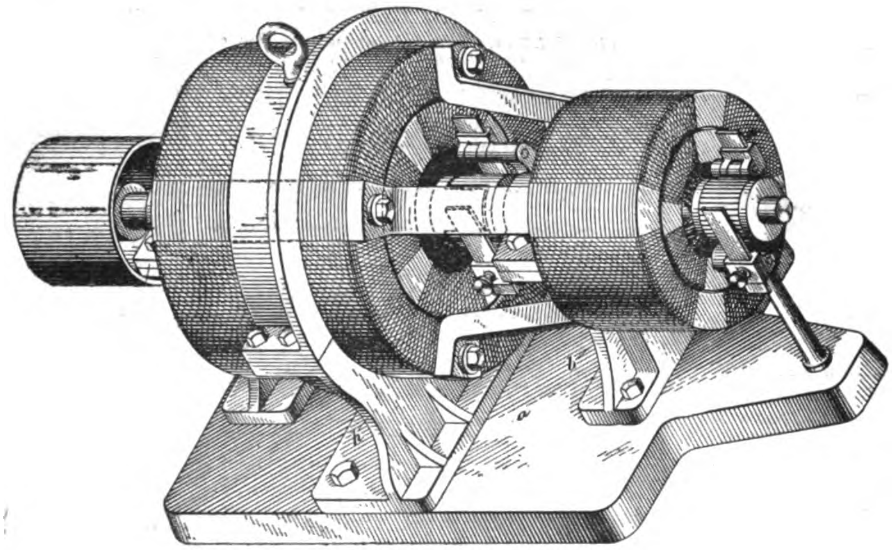

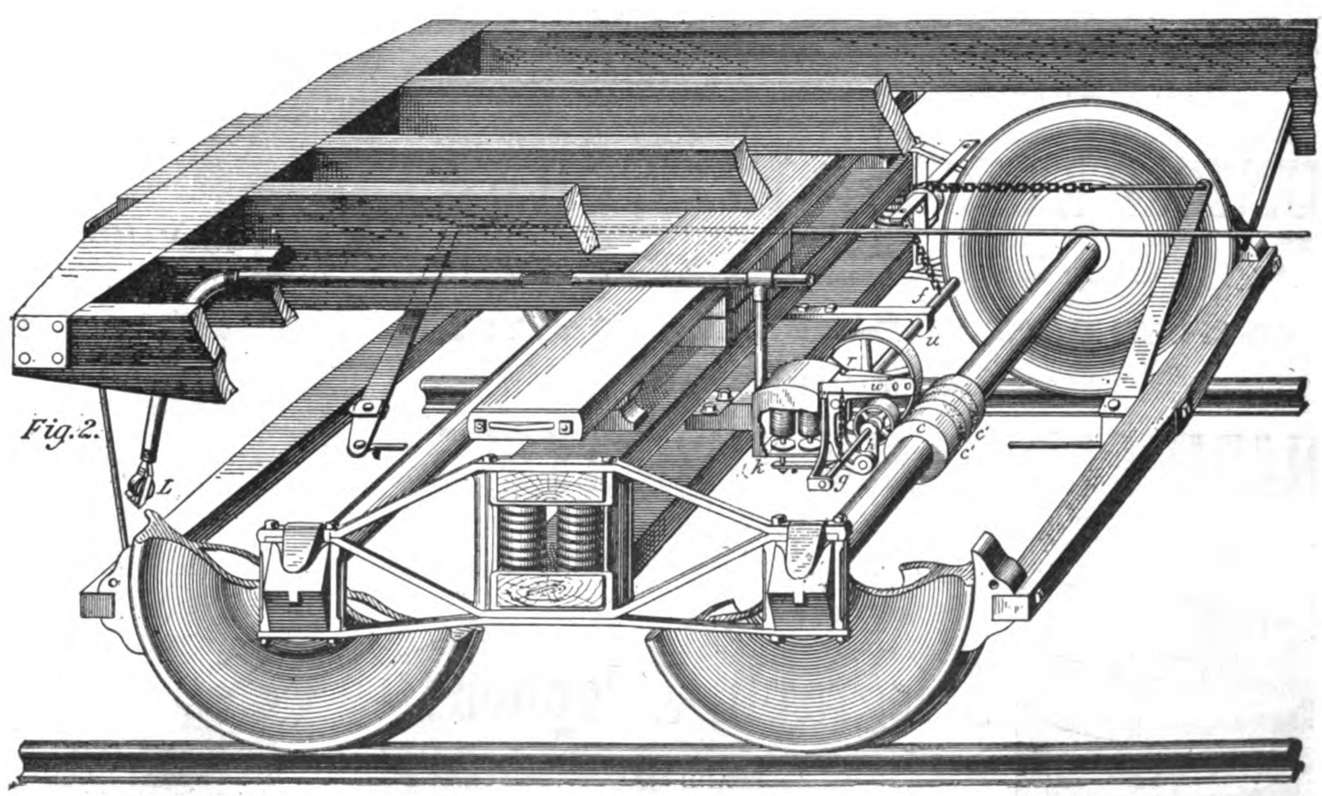

Fig. 2.

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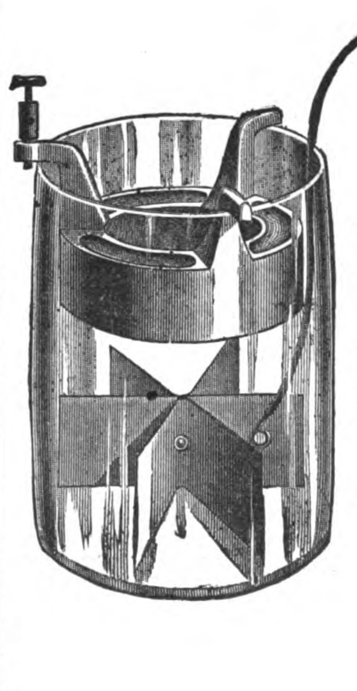

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PROSPECTUS FOR 1889.

The field, which this journal is to occupy, has upon investigation developed beyond the original expectations of its founders; who have, however, from the earliest stages of the electric motor business, appreciated its coming importance.

We do not pretend to forecast the future of the electric motor, yet we feel that a glance at our columns should convince every engineer, whatever may be his class, that its advent is of rapidly increasing interest in many fields where electricity has heretofore been an unknown agent.

We are well aware that technical journals are giving this subject attention, but none of them can fairly cover the field. We find gems of information scattered in out-of-the-way places, and it is only by industriously concentrating our efforts upon this particular line of work that its importance is impressed upon us. In order to show the adaptability of the electric motor to various industrial purposes, the following partial list is presented showing the variety of work it is now doing because of its Economy, its Reliability, its Cleanliness, its Simplicity, and its Compactness:

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Canning Machines
Cabinet Makers
Centrifugal Machines
Circular Saws
Cloth Cutting Machines
Cigar Box Machinery
Confectioners
Corn Dressing Machines
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Gunsmiths
Hydro Extractors
Hair Pickers
Hatters' Machinery
Hoisting Machinery
Hydraulic Presses
Hoisting Building Material
Harness Makers
Hair Picking Machines
Ivory Turners
Ice Machines
Ice Cream Freezers
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Jig Saws
Jewelers' Lathes
Kitchen Machinery for Hotels
Knitting Machines
Laundry Machinery
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Twisting and Spinning Machines
Ventilating Machinery
Whip Making Machines
Wood Working Machines
Watch Case Machinery
Washing Machines
Wax Thread Machines
Wire Covering Machines

As the field of this journal will be largely outside of electrical circles, it appears proper that its readers should know something of the experience of those who have undertaken its publication.

RALPH W. POPE entered business life in the steam railroad service in 1859, and subsequently learning telegraphy by the Hughes Printing, and Morse systems, has since been actively engaged in electrical pursuits. He was associate editor of *The Electrician* and *The Electrical Engineer*, for over two years, and has since been engaged in literary work for various electrical and mechanical papers, both foreign and domestic. He is a member of the New York Press Club, an associate member of the American Institute of Electrical Engineers, and has been its Secretary since 1885.

GEORGE H. STOCKBRIDGE, was for three years an Examiner in the Electrical Division of the United States Patent Office, and a practicing patent solicitor for five years. He was connected with the *Electrical World* for two years as Editor of the Patent Department. He is an associate member of the American Institute of Electrical Engineers.

HENRY W. POPE has been actively engaged in various branches of electrical industry since he entered the telegraph service in 1862. He was one of the original founders of the District Telegraph Service, and organized various existing companies. He was among the earliest of electricians to appreciate the future commercial importance of the telephone and the electric light, and still retains an interest in several electric light and power companies. He organized the National Telephone Exchange Association, of which he is an honorary member, and is also a member of the National Electric Light Association, and the Electric Club of New York. He is to-day a firm believer in the future of electric power transmission.

ELECTRIC POWER will be devoted to the joint interests of its subscribers, its advertisers, and its proprietors. Its aim will be the publication of valuable and interesting information, and the stronger its support, the more thoroughly will this duty be performed.

The Subscription price of ELECTRIC POWER has been placed at $3.00 per annum for the reason that its field is growing so rapidly, that it appears probable a decided enlargement or more frequent issue will be necessary in the immediate future. We recognize the fact, however, that at the outset the amount of reading matter we offer is not equal in quantity to that given by the general electrical journals, and we therefore make the following offer to our readers:

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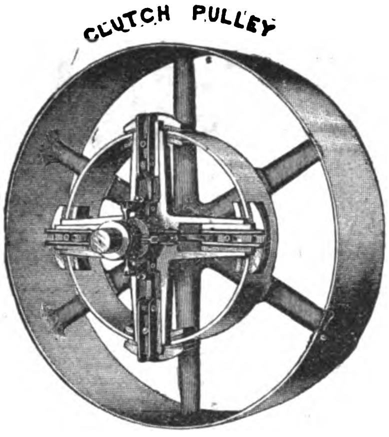

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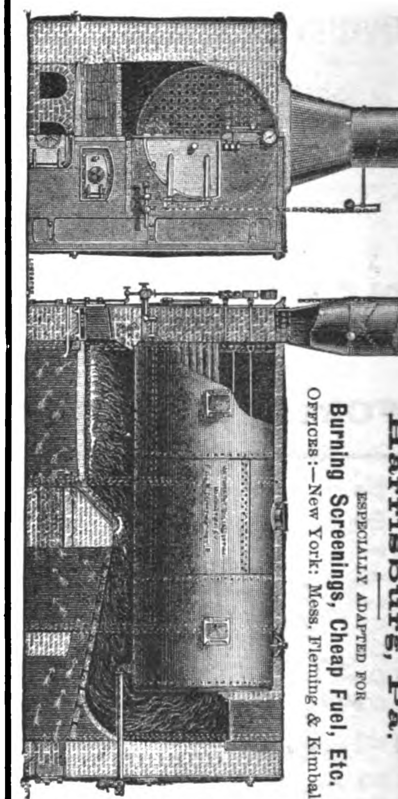

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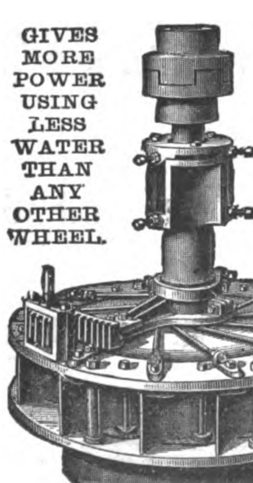

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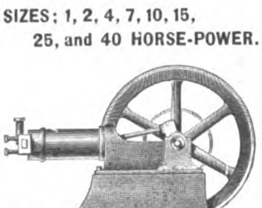

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